TIIM

Proceedings of the 2014 International Conference on Technology Innovation and Industrial Management

28th–30th May 2014
Seoul, South Corea

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THE GREENING OF ACCENT LIGHTING IN FOOD RETAIL: FUNCTIONS AND EMOTIONS

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ABSTRACT

Purpose: The main purpose of the research paper is to highlight the importance of greening processes in food retailing both from functional aspects (lowering the costs) and consumer aspects as well (visible and hidden consumer reactions and emotions). The balance between functions and consumer emotions is very important, so in the paper there are discussed various solutions of visual merchandising in practice of food retail and especially, the role and function of accent lighting have been investigated.

Design/methodology/approach: Using a Colour and Lux Meters we found out the intensity and color temperature of accent lighting used in food retail chains for the different kinds of fresh food products (visual comfort). We also identified different types of accent lighting which we assigned to their impact on emotional involvement of consumers. The starting points were the tests we conducted in simulated laboratory conditions. While searching of a compromise between effective and energy efficient accent lighting we take into consideration consumers' emotional response as well as the annual electricity consumption of different types of light sources. The second phase of the research consisted of consumers' neurological tests. The wireless EEG device was set on the respondent's head to read its brain activity in real time.

Findings: With the rational using of combination of energy saving and effective accent lighting retailers can achieve not only attractive presentation of displayed products but also appreciable savings in the operation of their stores.

Originality: Submitted research paper accounts original research of team of experts at the Faculty of Economics and Management of the Slovak University of Agriculture in Nitra. This work was co-funded by European Community under project no 26220220180: Building Research Centre "AgroBioTech" and the Ministry of Education of the SR as a part of research project VEGA 1/0874/14: Use of Neuromarketing in Visual Food Merchandising.

Keywords: retail, accent lighting, energy efficiency, merchandising, customer, emotions

STRATEGIC THINKING ON TECHNOLOGY CATCHING-UP IN CHINA

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ABSTRACT

Technology catching-up, as a specific phenomenon in the process of economic growth, is of great practical significance and becoming more and more important both for advanced and backward countries. Under the background of the integration of the world economy and the transformation contexts of China's economic development, study on technology catching-up with independent innovation has become one of hot issues discussed among the government, academia and industry. In the law of technology catching-up, independent innovation is more important than everything. Chinese firms have been actively exploring technology catch-up path, some have achieved impressive results. However, many industries in present China are still dominated by foreign brands. In this context, to realize advanced industries driving other industries, advanced enterprise driving backward ones and then accelerate the catching-up process is becoming reality facing Chinese firms and government. Based on the above, this article focuses on discussion on Chinese technology catching-up strategy, path selection and policy model. The basic frame is formed from open collaborative innovation to independent innovation and then to technology catching-up, boosted by open innovation network and ecological innovation system, coupling mechanism of technology and market, university-industry collaboration, industrial chain collaboration, regional cooperation, company collaboration, and by taking measures of crowd sourcing innovation, R&D globalization, common technology breakthrough, intellectual property rights protection, patent strategy, market leading, so that achieve upgrading of core technology, key industries, key areas and leading enterprises. Policy system model is built through three dimensions of basic policy tools (supply, environment and demand), technology catching-up domains (country, region, industry and enterprise) and technology catching-up types (accelerating, leaping and jumping).

Key words: technology catching-up, strategy, policy, China

BACKGROUND OF TECHNOLOGY CATCHING-UP IN CHINA

Since 20th Century, successful countries in technology catching-up continue to appear. From USA successfully overtaking the United Kingdom at the early 20th Century, Japan in the 1970's success to catch up with Europe and USA, to South Korea and Singapore successfully catching up with Europe, without exception, demonstrated

the developing countries or economy rapidly catch up with and even surpass the leading countries. In the time of economic catching-up, different forms of technology introduction, learning, cooperation, innovation and change being rich in, successful technology catching up in leading market development, play an important role in industrial upgrading and economic transformation. The theoretical research on technology surpassing and leapfrogging in China has made some achievements in recent years, some progress is made in leading technology and key technology, however, the development of core and new technology with independent intellectual property rights, compared with developed countries, still has a big gap. At the time of China entering a crucial period to build a well-off society, deepen reform and accelerate the transformation of economic development, the role of technology in economic development has become increasingly prominent, new scientific and technological revolution and global industry change is speeding up, to catch up with the development of science and technology in China faces with not only important strategic opportunity but also grim challenge, theoretical support and policy guidance are imperative.

Time background: knowledge economy being just unfolding, technology competition being like a raging fire

In 21st Century, knowledge makes a spurt of progress than any one era of past. The advent of knowledge economy era has been changing human society, the way we live and the way of our thinking. The situation of globalization based on both knowledge and information and both opportunities and challenges formed. Viewing from international scope, various countries including USA, Japan, South Korea and India, all invest heavily in the upgrading of technology, high-tech research and development and technology absorption and transformation. Technical competition is globally spreading.

International background: Global competition being complicated and changeable, technology sovereignty dispute being intensified

The tacit and contextual characteristics of knowledge as well as the abstract and environmental characteristics of science and technology make competition based on knowledge and technology as the basic elements of the global scope become more complex and non equalization. The geographical distribution of technical difference is an important manifestation of the non equalization. Developed countries often occupy the leading position in R&D, witnessed the emergence of many technologies, and the rises and falls of technology changes, and try to grasp the right of words in technical evolution. They get the market opportunities by creating first mover advantage in information and further maintain and expand this advantage through network externalities and positive feedback mechanism. This makes the developing countries "black box" decryption road face technical barriers and strict technical blockade. However, the developing countries may have advantage of backwardness in development cost and risk control and have an insight into technology noncontinuity, uncertainty of consumer demand and market scale. Complex of competition and backwardness advantage have prompted developing countries looking for technology development path in order to share a

cup of a thick soup in technology upgrading or evolution, and even the title of new technology.

Domestic economy: industrial structure being ready to upgrade, technology catching-up strategy being imperative

At present, China is in the key period of transformation of the mode of economic development and upgrading of industrial structure. Improvement of industrial structure performs coordinated development of industry and structure maximization. Behind a series of reforms, technological progress is an important supporting element for industrial upgrading. China, as one of the developing countries, needs to focus on the development trend of science and technology, establish advanced consciousness, strengthening pre study on cutting-edge technology and new concept of technology, emphasize independent innovation of major and key technology, strives to develop key technologies and products with independent intellectual property rights. However, reality is: though China is in the leading level in photovoltaic, new energy and some other areas in the world, China is still in the relatively backward position in most industries. Then, based on the Chinese economic development and social management practice, to formulate feasible technology catching-up strategy in order to catch up with advanced technological level is imperative.

Technology trends: technology catching-up path being lumpy, opening independent innovation being imminent.

From the history of different countries catching-up, technology introduction for late comers in technology surpassing is a feasible path. However, exogenous feature of technology and leaping characteristics of technology upgrade make technology introduction sometimes imply great trap. This trap may make technology importing countries R&D appear hollow, weaken the ability of local R&D, and be more and more dependent on foreign technology. Therefore, excessive dependence on technological evolution path is not conducive to the realization of technology catching up, and to emphasize path creation in the absence of path dependency basis may fall into competence trap. For China in the transition period, it is even more so. We cannot completely depend on introduction of foreign technology, but also not completely close technology catching-up. We should create balance in path dependence, path transition and path creation. It is imminent to promote independent innovation and independent intellectual property rights with many alternative technology roads for China.

Throughout present situation of industry development in China, many industries are still dominated by foreign brands. Of course, some industries and enterprises have realized the importance of independent innovation and technology catching up, such as commercial aircraft manufacturing industry, electric car industry, and in invested a lot of money in technology research and development. However, the performance is not in technology innovation, but in investing in mines or real estate. In this context, whether advanced enterprises can drive the others to accelerate independent technology innovation in

China become a reality we have to face.

Research trends

Technology catching-up, as the specific phenomenon of economic development, is a problem of great practical significance. It is becoming more and more important for both advanced countries and backward countries. The current research on technology catching-up, on the whole, is still relatively scattered, has not formed a systematic situation,

The establishment of development economics and endogenous economic growth theory inspired the study on economic catching-up. As an important branch of development economics, the interaction between technology catching-up and economic development is interaction of knowledge and industry, interaction of enterprise strategy and national strategy. Although this viewpoint has been widely accepted, but further research is needed. The existing research is mainly on technology catching-up phenomenon, lack of comprehensive integration of catching-up modes.

Scholars mainly pay attention on technological competency of both micro enterprise and macro national level. Study on meso level of industrial and regional technical ability is rare. Technology ability of industry and region is not equal to sum of single enterprises, and is also not miniature version of national technical competency. For a developing country like China with great regional differences in technological ability, regional level must give more attention. The lack of research on meso level leads us lack of knowledge on relationship between these core elements, their interaction and how to evaluate them.

Scholars focusing on technology catching-up pay more attention to specific mode of technology catching-up, lack of research on catching-up strategy. As a developing country, Chinese regional economy and competency presents obvious difference, this also lead to huge difference in technology catching-up strategy between China and the countries like South Korea which have succeed in catching-up. Therefore, we are required in technology catching-up strategy research to give more consideration on spatial and temporal characteristics of strategy and make multi level, stepped technology catching-up strategy system.

Research on technology catching-up path based on Chinese context is more dispersed. Current study mainly focuses on the study of South Korea, Singapore and other countries. Chinese study must consider regional heterogeneity, unbalanced development of industry, inhomogeneity of enterprise scale and strength, more need to put region, industry, enterprise and technology linked, not only reflecting integration path of technological catching-up in common, but also contain segment paths of catching-up at different single parts.

Policy research on technology catching-up in China is only general strategies.

Theoretical thinking is insufficient. So, this paper tries to form a theoretical policy frame for Chinese technology catching-up.

Based on the above, this paper will focus on Chinese context to discuss strategic problems of technology catching-up, mainly catching-up path and policy system.

CHINESE CONTEXT FOR TECHNOLOGY CATCHING-UP

Strategy of national innovation system with independent innovation is a significant strategic adjustment in the new century China government made. As a developing country, in order to realize the technology catching up, Chinese mode of technology progress should be organic combination of technology catching-up strategy and independent innovation, and gradually realize independent innovation from technology imitation. Chinese context of imbalance development of regional economy and extremely uneven in technological level, R&D resources, without doubt, will affect the diversity and multi-level of technology evolution and industrial evolution trajectories.

Chinese context in technology catching-up may include:
(1) Context in theoretical study of technology catching-up: multivariate innovation based on oriental culture.
(2) Context in Chinese government function of technology catching-up: system innovation based on Chinese traditional management ethics.
(3) Context in social network and social capital of technology catching-up: communitarianism based on Chinese tradition.
(4) Context in theoretical study on regional technology catching-up: Chinese angle based on local government competition.

CHINESE PATH TO CATCH UP IN TECHNOLOGY INNOVATION: THE ANGLE OF COORDINATION AMONG INNOVATION SUBJECTS AND DOUBLE TRACK COUPLING.

At present, China is in the key period of transformation of economic development mode and industrial structure upgrading. In the law of technology catching-up, independent innovation is more important than everything, and innovation is a multi-stage process involving many subjects.

From the overtaking road in high-speed railway, key technology breakthrough gathered many China universities, scientific research strength under the energetic efforts of Chinese government, forming a crisscross innovation network with interconnected structure. However, from the existing statistical data, most research funding of research institutes and colleges still come from government, scientific cooperation between enterprises still need

to improve. Therefore, recognition of collaborative innovation mechanism between different innovation subjects is the most important issue for China's technology catching-up.

On the other hand, in the process of technology catching-up and independent innovation, both following path along the existing track and path with skipping some phases, or creative path opening up new technical track, cannot ignore interaction and coupling of both technology catching-up and overtaking of market. Technology innovation and evolution, only closely combined together with market demand, can realize its real value. Otherwise, can only be shelved patent.

Framework of Chinese path to catch up

In view of the above, we design catching-up path architecture from open collaborative innovation to the independent innovation and technology catch-up (Figure 1), including one context (Chinese context), one platform (open innovation network, innovation ecosystem and "cloud" platform combined), two boosting mechanisms (coordination among innovation subjects + technology coupling with market), eight booster (collaboration among industry, research institute and university + collaboration of industrial chain + regional collaboration + company collaboration + technology introduction + technology imitation + second innovation + business model innovation), six implementation terms (crowd-sourcing innovation + globalization of R&D + generic technology breakthrough + protection of intellectual property rights + patent strategy + market leading) and four areas (core technology + key industry + important regions + leading enterprises).
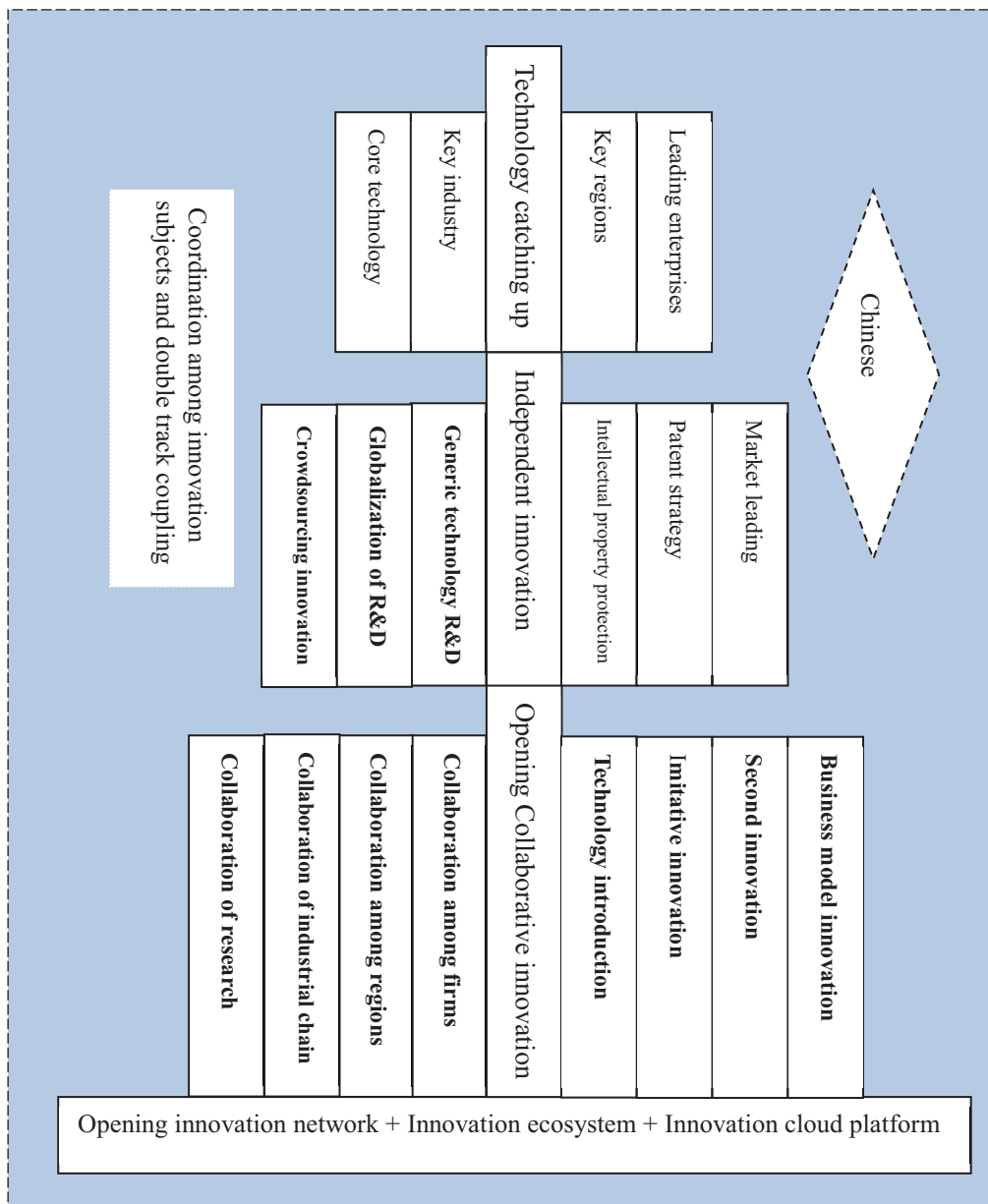
Fig.1 Framework of Chinese path to catch up with the independent technology innovation

Based on the above framework, Chinese technology caching-up path selection model is constructed in Figure 2 from national, regional, industry and enterprise levels.

National level: technology catching-up path with government pushing

This may contain: (1) the path with system innovation, formulated by state technology development policy to lead regional technology development and further lead industry and enterprise to achieve technological catching-up; (2) the path with feedback technology, formulated by enterprise catching- up leading industry and then further fuelling regional and country's caching-up to realize technology catching-up from the bottom to the top; (3) the path with collaborative innovation, formulated by making joint efforts from

government, region, industry, enterprise and other factors to realize the caching-up goal based on collaborative effects of system, organization, culture, resource and other dimensions.
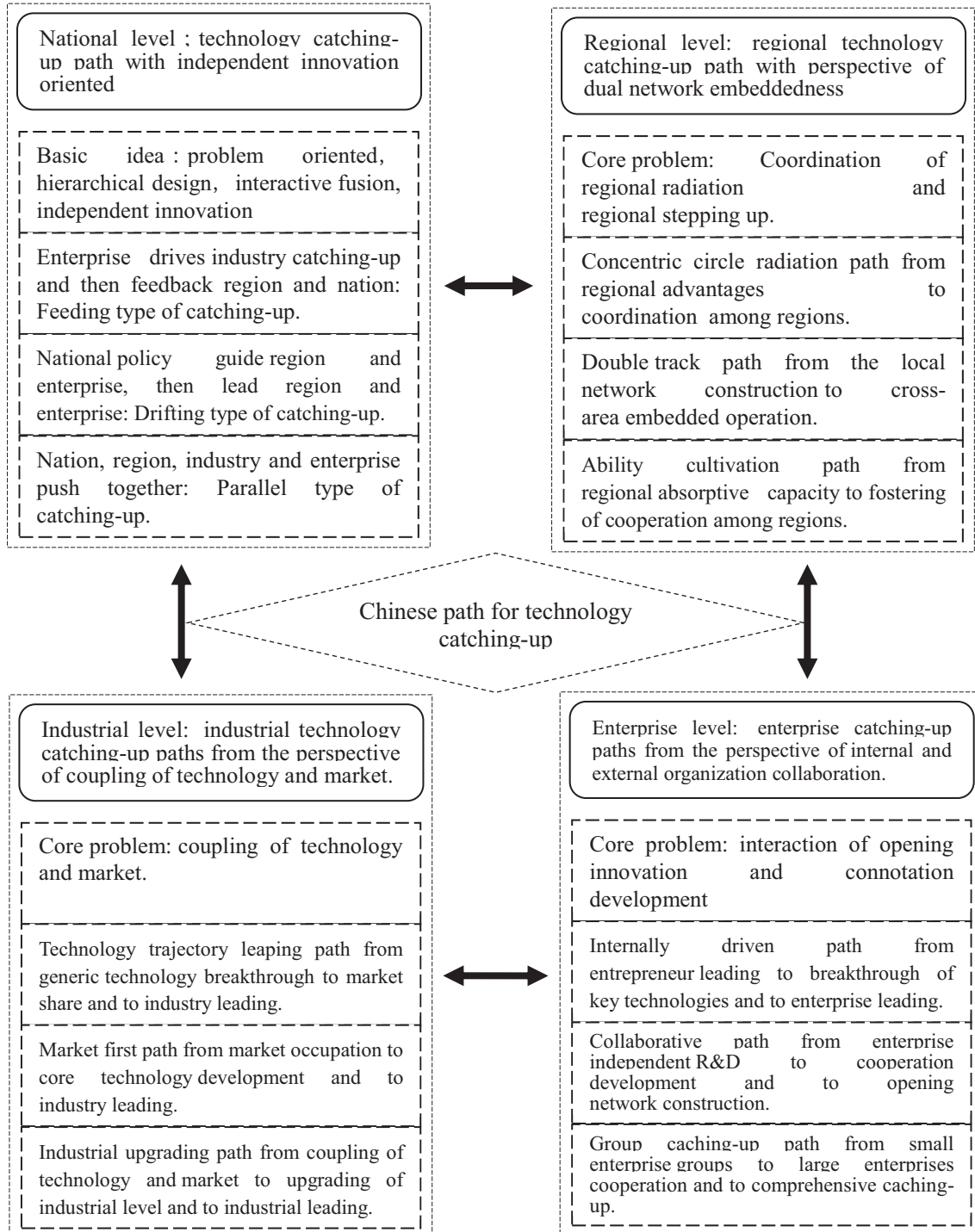
Fig. 2 Path selection to catch up with independent innovation in China

Regional level: regional technology catching-up paths with perspective of dual network embeddedness

This may contain: (1) the path of concentric circle radiation from the regional advantages to interregional synergy; (2) the path from local industry and enterprise network construction to dual track cross-network embedded; (3) the path of technological capacity cultivation from regional absorptive capacity ascending to interregional cooperation.

Industrial level: industrial technology catching-up paths from the perspective of coupling of technology and market.

This may contain: (1) the path of technology track transition from industrial generic technology breakthrough to market share and to industry leading; (2) the path of market preferred from market occupation to core technology development to industry leading; (3) the path of industrial upgrading from coupling of technology and market to upgrading of industrial level and to industrial leading.

Enterprise level: enterprise technology catching-up paths from the perspective of internal and external organization collaboration.

This may contain: (1) the path internally driven from entrepreneur leading to breakthrough of key technologies of enterprise and to enterprise leading; (2) the path of collaborative innovation from enterprise independent R&D to cooperation development and to opening network construction; (3) the path of group caching-up from small enterprise groups to large enterprises cooperation and to comprehensive caching-up.

POLICY SYSTEM: THE PERSPECTIVE OF POLICY TOOLS

Structure level of Chinese policy tools for technology catching-up

Based on the analysis of catching-up paths, various policy tools to drive technology catching-up strategy of China may be distinguished from several dimensions. These policy tools are: (1) basic layer of policy tools (tax incentives, financial support, education and training, scientific research funds, government procurement, intellectual property protection, trade control, leading talent and innovation team training); (2) intermediary layer of policy tools (intermediary service of science and technology, science park of university, innovation fund for small and medium firms, characteristic industry base); (3) strategic policy tools (national science and technology development planning, regional science and technology development planning); (4) supportive policy tools (innovation atmosphere construction, innovation culture and so on).

Matching of construction of policy system and policy tools in China: three-dimensional model

Firstly, the basic policy tools are classified into three types of supply, demand and environment as basic policy dimension X in model construction. Secondly, technology catching-up in China may occur at the national level, regional level, industry level and

enterprise level, so this is defined as technology catching-up dimension Y. Then, technology catching-up contains paths of accelerating, leaping and jumping types, so this is defined as catching-up type dimension Z.

Therefore, we establish the three-dimensional model of Chinese technology catching-up policy tools (Figure 3). Dimension X is basic policy tools (supply, demand and environment), dimension Y is surpassing domain (national, regional, industry, enterprise), dimension Z is technology catching-up types (accelerating, leaping and jumping).
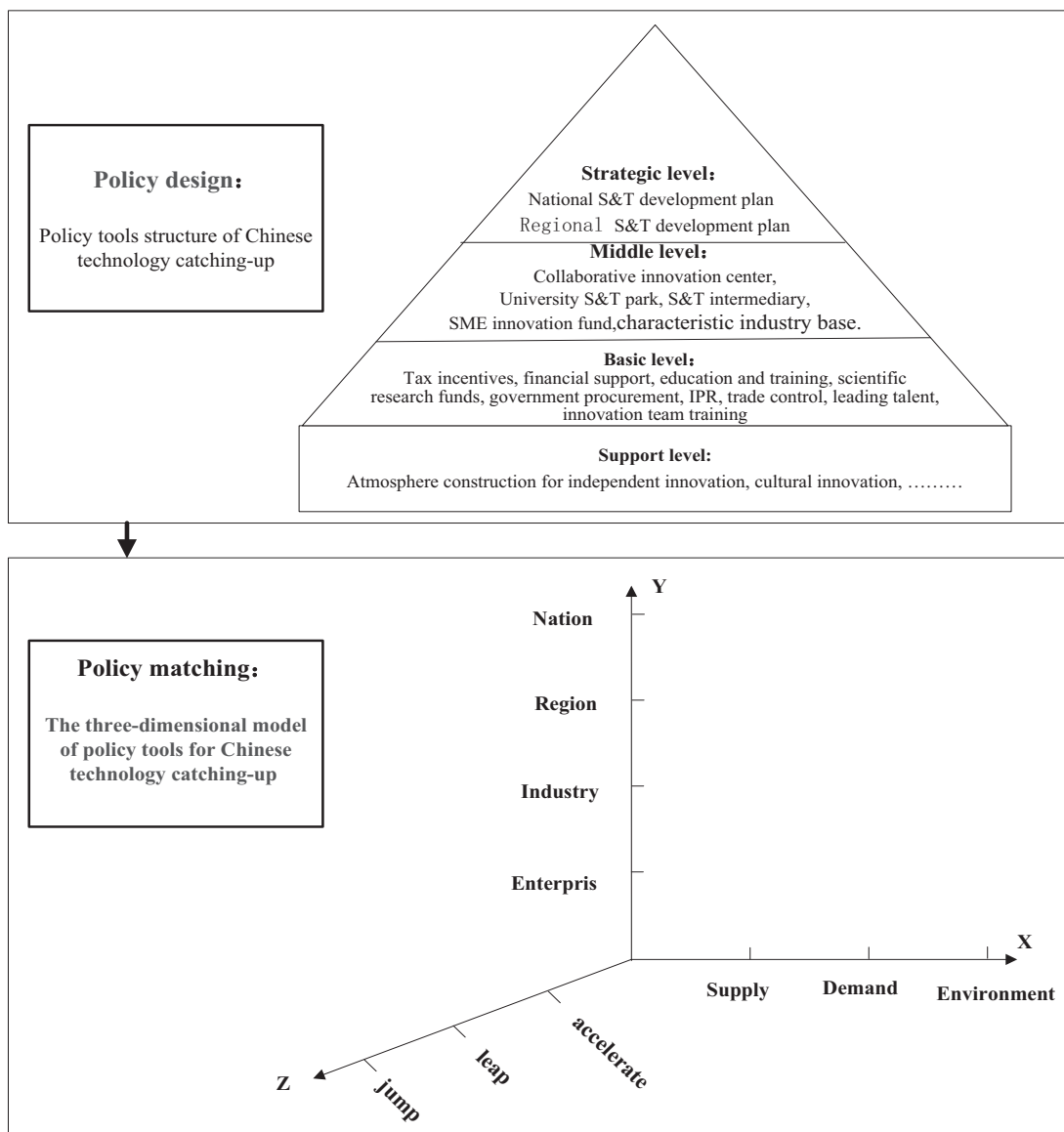
Figure 3 Three-dimensional model of policy system with perspective of policy tools

CONCLUSION

Technology catching-up, as a specific phenomenon in the process of economic growth, is of great practical significance and becoming more and more important both for advanced and backward countries. this paper discussed background for Chinese technology catching-up from time, international, domestic, technology, research aspects at first, and then illustrated Chinese context for catching-up. Secondly, Chinese path to catch up was designed from perspective of coordination among innovation subjects and double track coupling at national, regional, industrial and enterprise levels, respectively. Three-dimensional model of policy system with perspective of policy tools for technology catching-up.

ACKNOWLEDGEMENTS

REFERENCES

1. Beers, C., Berghall, E., Poot, T. (2008). R&D internationalization, R&D collaboration and public knowledge institutions in small economies: Evidence from Finland and the Netherlands [J]. Research Policy, Vol.37, pp.294-308.
2. Chen, D. Z., Li-Hua, R. (2011). Modes of technological leapfrogging: Five case studies from China [J]. Journal of Engineering and Technology Management, Vol.28 (1-2), pp.93-108.
3. Gottinger, H. W. (2006). Global technological races [J]. Japan and the World Economy, Vol.18 (2), pp.181-193.
4. Malerba, F., Nelson, R. (2011). Learning and catching up in different sectoral systems: evidence from six industries [J]. Industrial and Corporate Change, Vol.20 (6), pp.1645-1675.
5. Varblane, U., Dyker, D., Tamm, D. (2007). How to improve the national innovation systems of catching-up economies? [J]. Trames, Vol.11 (61/56), pp.2.
6. Chen, J., Liu, X.(2008). Independent innovation and national prosperity [M].Beijing：Science Press.
7. He, J. (2012). Forming path of innovative enterprises: empirical analysis based on technical competence and function of innovative strategy [J]. Chinese Soft Science，Vol.27(04）：143-152.
8. Ou, Y.，Sheng, Y. (2008). Technology gap, technical capacity and technology catching-up of backward areas [J]. Chinese Soft Science，Vol.23（2）：153-160.

9. Wang, D., Kong, Y.(2012). Achieve technological catch-up under open conditions [J]. World Economy Research，Vol.31（2）：3-9.

10. Miao, W., Wu, X., Lan, J.(2007). Technological catching-up with ability reconstructing [J]. R&D Management，Vol.19（4）：16-21.

SOCIALIZATION IN ONLINE BRAND COMMUNITY AND BRAND LOYALTY

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ABSTRACT

Purpose: *This paper applies organizational socialization theory to understand motivators that influence members in different stages of a socialization process continue participating in online brand community (OBC) activities. OBC members are classified into different stages of socialization, and hypotheses are derived to identify motivators in each stage and their evolution as the members transit from the peripheral to the core of the communities.*

Design/methodology/approach: *The research model is tested on the data collected from 518 OBC users in South Korea through questionnaire survey.*

Findings: *The findings indicate that the motivators identified based on a socialization process can explain the intention to participate in OBCs and there are cause–effect relationships among the motivators in different stages of socialization. Members in the core of the communities have a stronger perception on the motivators than those in periphery.*

Research limitations / implications: *This study is one of the first efforts to understand OBC from socialization perspective. Data was collected from user initiated OBCs therefore the interpretation should be careful for company initiated OBCs.*

Practical implications: *The managers of OBCs need different strategies to retain OBC members according to their stage of socialization processes.*

Originality/value: *This study integrated theory of reasoned action and organizational socialization theoretical frameworks for better understanding of the use behavior of OBCs.*

KEY SERVICE ELEMENTS OF BUSINESS DISTRICT ORGANIZATIONS AND SHOPS

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ABSTRACT

Purpose: *We apply the four dimensions of Dramaturgical Theory – setting, actors, audience, and performance – to discuss a Business District as two Dramaturgies according to the Behavior Model. Dramaturgy α is called "Business District Organization and Shop", and Dramaturgy β is called "Shop and Customers". We use these two Dramaturgies to develop questionnaires. Through questionnaires, we discover the important Service Elements by using Grey Relational Analysis, so we can give advice to both Business District Organizations and Shops. We can then apply the important Service Elements in analyzing other countries, to promote their Service Quality.*

Findings: *The research outcome in Dramaturgy α gave us a list of 14 important Service Elements. We classified these 14 items in three ways with respect to their application in practice: Communication with the Government, Business District Environment, and Communication with Shops. Service Quality can be promoted by concentrating on these items. The research outcome in Dramaturgyβgave us13 important Service Elements between Shops and Customers, which were also classified in three ways: Shop Environment, Promotion Strategy, and Equal Service. This analysis can be used to promote Service Quality.*

Practical implications: *The important Service Elements developed by our research in Taiwanese Business Districts and Shops can be applied to other Business Districts in other countries to promote Service Quality between Business District Organizations and Shops.*

Originality/value: *The important Service Elements developed by our research in Taiwanese Business Districts and Shops can be applied to other Business Districts in Taiwan to promote Service Quality between Business District Organizations and Shops.*

Keywords: Business District, Dramaturgical Theory, Grey Relational Analysis, Service Element, Taiwan.

Paper type: Research paper

INTRODUCTION

In response to leisure tourism and changing consumption patterns, the famous "Business Districts" of six continents have developed with different characteristics in a multicultural way. Some Business Districts include:

Asia: *Taichung, Taiwan*: Yizhong Street Business District; *Shanghai, China*: Nanjing West; *Harajuku, Japan*: Takeshita-dori Shops; *Seoul, Korea*: Myeongdong Business District; *Bangkok, Thailand*: Siam Square.

Europe: *London, UK*: Oxford Street; *Paris, France*: Champs-Elysées.

Africa: *Gauteng, South Africa*: Sandton City.

Oceania: *Sydney, Australia*: Pitt Street Mall.

North America: *New York, U.S.A*: Times Square.

South America: *Buenos Aires, Johannesburg.*

In such districts, shops often form "Business District Organizations" promoting local affairs, in order to provide the best service for customers. In this research into the world's leading Business Districts, the different characteristics of some of Taiwan's 101 specialty shopping districts are studied in order to analyze important Service Elements of Business District Organizations and Shops in Business Districts. Then, the ways to improve application of the most important Service Elements to promote Service Quality are suggested.

In the global economy, in the era of liberalization and internationalization, national Business Districts exist in a dynamic competitive environment. Therefore, Business District Shops must understand the importance of Service Elements which are customer-focused, working to improve and achieve service quality improvement. In this study, the four dimensions of Dramaturgical Theory – setting, actors, audience, and performance are applied to discuss this particular Business District in terms of two Dramaturgies according to the Behavior Model. Dramaturgy α is called "Business District Organization and Shop", and Dramaturgy β is called "Shop and Customers". These two Dramaturgies are used to develop questionnaires. Through questionnaires, the important Service Elements are discovered by using Grey Relational Analysis. Based on these elements the suggestions for improving the "Business District Organization and Shop" relationship can be provided. Then, the important Service Elements are applied to other countries to suggest improvements in their Service Quality. Research results are expected to provide the countries' Business District Organizations and Shops with reference points to improve

the quality of service. This will enable Business Districts to stand out in their countries, to achieve their purpose of marketing the city, and to stimulate regional economic development.

LITERATURE REVIEW

This section describes research into the literature concerning the definitions of "Business District" and "Business District Organization," and the four dimensions of Dramaturgical Theory: setting, actor, audience and performance.

The definition of Business District

According to the literature, "Business District" in the academic literature has both broad and narrow senses. The broad definition of "Business District" entails a geographical area where Shops s are clustered, which is a recognized destination for customers. Getz (1993) defines a Business District by the composition of its consumers; for example, a visitor-oriented Central Business District will be called the Tourism Business District and seek to attract tourists. The narrow definition specifies a Shops as the core of its customers by their geographic distribution, which is the source range of those customers. Huff (1964) argues that a Business District signifies the geographic area of the customers or potential customers for a particular Shops 's products or services, with all in this region having the opportunity to purchase. In this study, the broader definition of "Business District" is adopted. Business Districts are aggregations of two or more Shops, and consumers will go shopping in the well-known geographical area where these Shops group. This describes most Business Districts worldwide, such as Yizhong Street Business District in Taichung (Taiwan), Times Square in New York City (NYC), Seoul's Myeongdong shopping district, and so on.

The definition of Business District Organization

Our research looked at the definition of Business District Organizations in the scholarly literature. Business improvement districts, for example, provide many additional services beyond basic government services, such as: additional maintenance of law and order, reducing crime and enhancing the downtown business area's value (Meltzer, 2012). According to NYC Small Business Services (2013), "commercial promotion" refers to a particular area where property owners and businesses are willing to pay taxes so as to provide additional services to make the business district a good business environment. Therefore, in this research, the definition of Business District Organization as an organization which interacts with consumers and residents in a Business District is used. Shops will form a "management committee" through voting, and the Organization may take on tasks such as upgrading the Business District's image and reputation, establishing a management protocol, announcing bulletins and resolving disputes in or between Shops. In this study, the "Management Committee" of the Business District

Organization was established to help promote the local district's affairs and improve the quality of the Business District's services.

The definition of setting

According to the literature, "setting" in the service sector is used to mean "the physical environment for providing services" – that is, where service delivery occurs (Bitner, 1990). The scene is divided into Front Stage and Back Stage. Front Stage is the place of "service delivery", interacting with customers directly, providing services to consumers in the process. Back Stage refers to "service operations" which are not normally seen by the public. It means the preparation and processing needed to provide the product or service (Grove et al., 1992; Lovelock, 2001).

The definition of actors

According to the literature, "actors" in the service industry are those involved in "service delivery", as the first line of contact with staff and customers in the service process (Mattson, 1994). Interaction between service personnel and customers will directly affect customer satisfaction.

The definition of audience

According to the literature, in this research "audience" is defined as "customers" in the service delivery process. Since the service is simultaneously in the process of production and consumption, the customer does not stay out of it, but is directly involved in the whole process of service delivery. The customer can also affect the service outcome by their behavior (Parasuraman et al., 1985).

The definition of performance

According to the literature, in this research "performance" is defined as "interaction between customer (the audience) and service (actor)" in the service industry. In other words, "performance" is the main result of the service contact. The service organization combines actors (service personnel), the audience (customers) and scene (where services are provided), thus creating a credible performance. Coordination between the various elements of the performance is the key to success (Grove et al., 1992).

RESEARCH APPROACH

We analysed the literature's use of the concepts of "Business District" and "Business District Organization", and the four dimensions of Dramaturgical Theory: "setting", "actor", "audience" and "performance". Next, we defined all of the above.

Hereinafter, we examine three Business Districts which have different characteristics among Taiwan's 101 specialty Business Districts. We apply Dramaturgical Theory as a framework to separate a Business District into two Dramaturgies, according to the Behavior Model. Dramaturgyαis called "Business District Organization and Shop", and the other Dramaturgy β is called "Shop and Customers". We use these two Dramaturgies to develop two questionnaires, using the methodology of Grey Relational Analysis. The survey respondents in "Dramaturgy α" are shops in the Business District, and the survey respondents of "Dramaturgy β" are consumers in the Business District. Finally, our research extracts important"service factors" for Business District Organizations and Shops by "Grey Correlation Degree".

Designing the questionnaires
Our research integrates the definition of these four elements: "setting", "actor", "audience" and "performance". The three most famous business districts of Taiwan are the following: (a) "Shinshe Business District" in Taichung, a tourist attraction catering to the family market, (b) "Yizhong St. Business District" in Taichung, the district where teenagers like to go shopping; and (c) "Ximending Business District" in Taipei, where many international friends and young people love to go. Our research designed the questionnaires according to the literature. See Table 1 for the format of the questionnaire for "Business District Organization and Shop". See Table 2 for the format of the questionnaire for "Shop and Customers".

Table 1. Dramaturgy α: format for questionnaire of "Business District Organization and Shop"

Elements	Variables	Question	Source
Setting	Overall impression of Business District	1. Does the Business District Organization seek support from government?	Chao-Ho Wang (2008)
	Space allocation of Business District	2. Has the Business District Organization assisted with the route design of the Business District?	Kuo, Wei-Chi (2001)
		3. Has the Business District Organization provided accessible transportation in the Business District?	Wan-Ling Hsu (2005) ; Ghosh (1994)
		4. Has the Business District Organization organized the parking scheme of the Business District?	Kuo, Wei-Chi (2001)
	Environmental factors of Business District	5. Does the Business District Organization help to build the image of the Business District?	Chao-Ho Wang (2008) ; Priskin (2001)
		6. Does the Business District Organization lobby government and local society for better public facilities in the Business District?	Chao-Ho Wang (2008) ; Priskin (2001)
		7. Does the Business District Organization" improve the links between the Business District and nearby tourism?	Chao-Ho Wang (2008)
Actor	Dressing of Business District Organization' staff	8. Do employees of the Business District Organization wear a uniform?	Maye et. al (2003)
	Attitudes and behaviors of Business District	9. Does the Business District Organization regularly survey Shops on their satisfaction with its services?	Ching-Sung Lee et. al (2010)
		10. "Business District Organization" offer appeal way.	Ching-Sung Lee et. al (2010)

Elements	Variables	Question	Source
	Professional technology of Business District	11. Does the Business District Organization seek a hardware fund allowance from the government?	Ching-Sung Lee et. al (2010)
		12. Does the Business District Organization seek a software fund allowance from the government?	Ching-Sung Lee et. al (2010)
		13. Does the Business District Organization offer long-term tech support?	Ching-Sung Lee et. al (2010)
	Commitment of Business District to Shop Staff	14. Does the Business District Organization offer regular knowledge-sharing events?	Ching-Sung Lee et. al (2010)
		15. Does the Business District Organization have financial autonomy?	Ching-Sung Lee et. al (2010)
		16. Does the Business District Organization hold regular general meetings?	Ching-Sung Lee et. al (2010)
Audience	The attitude of Shop employees involved in service	17. Does the Business District Organization encourage Shop participation in planning?	This research
	The ability of Shop staff to participate in services and activities.	18. Does the Business District Organization have ideas for enhancing the identity of the Shops in the Business District?	Chao-Ho Wang (2008)
		19. Do Shops support and participate in the services provided by the Business District Organization?	Chao-Ho Wang (2008)
	The interaction between Shop staff.	20. Does the Business District Organization help Shops and other businesses exchange their experience?	This research
		21. Does the Business District Organization offer services for promoting different shops?	This research
Performance	Service quality of Business District Organization.	22. Does the Business District Organization improve and maintain public facilities?	Chia-Chun Lai, Li-ming Ho (2005)
		23. Does the Business District Organization maintain security in the	Chia-Chun Lai, Li-ming

Elements	Variables	Question	Source
		Business District? 24. Does the Business District Organization offer information about coordination and communication?	Ho (2005) Chia-Chun Lai, Li-ming Ho (2005)
	The customer service and effectiveness of the Business District Organization.	25. Can Shops communicate with the Business District Organization directly?	Chao-Ho Wang (2008)
		26. How quickly does the Business District Organization respond to questions from Shops?	Chao-Ho Wang (2008) ; Stoke (2008)
	The service process performance of the Business District Organization.	27. Are the Business District Organization's membership fees fair?	Ching-Sung Lee et. al (2010)
		28. Does the Business District Organization offer attractive promotional plans for the Business District?	Ching-Sung Lee et. al (2010)
		29. Does the Business District Organization offer diverse planning for the Business District?	Ching-Sung Lee et. al (2010)
	Comprehensive Performance	30. Does the Business District Organization offer Shops high consistency services?	Parasuraman et. al(1985)
		31. Does the Business District Organization offer reliable service?	Parasuraman et. al(1985)
		32. Are the office hours of the Business District Organization close to the business hours of the Shops?	Parasuraman et. al(1985)
		33. Does the Business District Organization give different types of services for different types of Shops?	Parasuraman et. al(1985)

Table 2 Dramaturgy β: format of questionnaire for "Business District Shop and customer"

Elements	Variables	Question	Source
Setting	The décor of the Shop	34. Does the Shop have distinctive decoration?	Hsu and Powers(2002)
		35. Are the Shop's decorations regularly replaced?	This research Hsu and Powers(2002)
		36. Does the Shop play music to enhance the atmosphere for customers?	Hsu and Powers(2002)
		37.Does the Shop set up the fresh smell equipment to enhance the atmosphere for shopping is important?	
	The allocation of space in the Shop	38. What type of customers visit the Shop?	Schiffman and Kanuk (2008)
		39. What kind of experience do the Shop's customers have?	Schiffman and Kanuk (2008)
	Cleanliness of Shop	40. Is the Shop a clean environment?	This research
Actor	Presentation of Shop staff.	41. Do Shop staff wear uniforms?	Hsu and Powers(2002)
	Attitudes and behaviors of Shop clerk	42. Are Shop staff dependable?	Chia-Chun Lai, Li-ming Ho (2005)
		43. Are Shop staff friendly?	Chia-Chun Lai, Li-ming Ho (2005)
	The professional and technical skills of Shop staff.	44. Can Shop staff give knowledgeable comments?	Li-ming Ho (2005)
		45. Do Shop staff have good product knowledge?	Li-ming Ho (2005)
		46. What are the language capabilities of Shop staff?	Shing-Chi Chang (2006), Bo-Shou Lin (2008) et. al
		47. "Shop clerk" adjust surgery content based on consumer characteristics.	Tzong-Ru Lee, Shing-Chi Chang (2006), Bo-Shou Lin et. al (2008)

	Description	Question	Source
	The commitment of Shop staff to customers.	48. Does the Shop offer its products at fair prices? 49. Do the services that the Shop offers correspond to its promotional content?	This research Chia-Chun Lai, Li-ming Ho (2005)
Audience	The attitude and willingness of consumers to participate in the service.	50. Do consumers participate in the Shop's online community? 51. Do consumers value the Shop's souvenir products?	Ching-Sung Lee et. al (2010) Ching-Sung Lee et. al (2010)
	The ability and willingness of consumers to participate in services.	52. Do Consumers identify with the Shop? 53. Do consumers regularly participate in the Shop's activities?	Chao-Ho Wang (2008) Chao-Ho Wang (2008)
	Interaction between the customers.	54. Do customers recommend this Shops to others?	Ching-Sung Lee et. al (2010)
Performance	The Shop's product quality	55. Does the Shop offer special services, such as Wireless Internet? 56. Are the products reasonably priced? 57. Is there a diverse range of products?	Ching-Sung Lee et. al (2010) Ching-Sung Lee et. al (2010) Ching-Sung Lee et. al (2010)
	Timely service job processing	58. Does the Shop rapidly respond to customer problems? 59. What does the Shop do to shorten waiting times?	Chao-Ho Wang (2008) Chao-Ho Wang (2008)
	The performance of the service process	60. Does the Shop offer good products and services? 61. Does the Shop offer after-sales service? 62. Does the Shop carry out satisfaction surveys regularly?	Ching-Sung Lee et. al (2010) Ching-Sung Lee et. al (2010) Ching-Sung Lee et. al (2010)

	Consolidated performance of Shop	63. Does the Shop offer consumers a high consistency of service? (For example: operating times are fixed, service items are non-discriminatory, etc.)	Parasuraman et al. (1985)
		64. Does the Shop offer consumers reliable service?	Parasuraman et al. (1985)
		65. Do the Shop's opening hours coincide with consumers' rush hours? (For example: most consumers commute to and from work at 8:00 and 17:00, so the Shops's business hours should extend as early as 8:00 and later than 17:00.)	Parasuraman et al. (1985)
		66. Does the Shop offer give different types of services to different types of consumers, such as families or couples?	Parasuraman et al. (1985)

Samples collected from questionnaires

Questionnaires in the "Business District Organization and Shop" format were handed out to 23 shops separately in the Shinshe, Yizhong St. and Ximending Business Districts in April 2013. The total number of questionnaires was 69, of which 59 were valid. The respondents to these questionnaires were Shops. Our research used SPSS 19.0 to perform descriptive statistical calculations. In this survey, questionnaires were answered by 22 shops in Shinshe, 21 shops in Yizhong St. and 16 shops in Ximending.

Questionnaires in the "Business District Shop and Customer" format were handed out to 110 customers separately in the Shinshe, Yizhong St. and Ximending Business Districts in April 2013. The total amount of questionnaires was 330, of which 296 were valid. The respondents to these questionnaires were customers. Our research used SPSS 19.0 to perform descriptive statistical calculations. In this survey, the largest category of respondents were private enterprise employees (29.1%), followed by students (17.6%).

Grey Relational Analysis

In this research, the "Grey Relational Analysis" method was used to analyze the questionnaires. By computing Grey correlation degrees, we aimed to discover those service factors which are most valuable to the customer. Grey Relational Analysis, proposed by Professor Deng Julong (1989), analyzes the degree of association of a discrete sequence. It uses the degree of similarity or dissimilarity between trends in various factors to measure the degree of association between these factors. Its steps are as follows:

1. On the Likert scale, 1means"strongly disagree: and 5 means "strongly agree"; these positive and negative options are called the "reference sequence". The raw data, in the form of returned questionnaires, is "relatively sequenced" (that is, less clear than the reference sequence), and the difference between the two is called "poor sequence". The smaller the value of "poor sequence", the closer the raw data is to the reference sequence, and thus the higher its relevance. The identity factor (ζ) is defined as0.5to compute the "Grey correlation coefficient (γ) value". For the formula of this calculation, please see Equation 1.

$$\gamma(x_i(k), x_j(k)) = \frac{\min_i \min_k |x_0(k)-x_i(k)| + \zeta_i^{\max} \max_k |x_0(k)-x_i(k)|}{|x_0(k)-x_i(k)| + \zeta_i^{\max} \max_k |x_0(k)-x_i(k)|}$$ (Equation 1)

2. After grey relational coefficients average out, the grey relational degree is obtained (Formula 1.2), which also represents the degree of association between the two sequences. If the two factors show consistent trend changes with a high degree of synchronization, the two are associated to a higher degree; otherwise, the degree of association is low. The formula for the calculation of grey relational degree is shown in Equation 2.

$$\gamma\big(x_i(k), x_j(k)\big) = \frac{1}{n}\sum \gamma\big(x_i(k), x_j(k)\big)$$

(Equation 2)

3. Finally, we arrange the values representing the degree of association between the two sequences in order, to form a relationship that is known as "grey relational order". The research thus computes the most important "service factors" in the order in which they are valued by customers, by the three steps of "grey relational analysis" above.

DRAMATURGICAL THEORY

Dramaturgyα: "Business District Organization and Shop"
We first used Dramaturgyα: "Business District Organization and Shop" to develop questionnaires. Through questionnaires, we found out the important Service Elements by using Grey Relational Analysis. We extracted the 14 most important "Service Elements" to which the Business District Organizations should pay attention, in order of "grey correlation degree". We classified these 14 items in three ways applied in practice: Communication with the Government, Business District Environment, and Communication with Shops. These are all ways which can be used to promote Service Quality (please see Table3). Service Elements: 1, 3, 11 and 12 were classified as "Communication with the Government". Service Elements: 4, 22, 23 and 28 were classified as "Business District Environment". Service Elements: 16, 19, 20, 24, 25 and 26 were classified as "Communication with Shops".

Table3: Applying GRA to extract the important Service Elements from Dramaturgyα

Dramaturgical Theory	Grey Correlation Degree	Question number	Classification of service elements
setting,	0.8644	1.	Communication with the Government
	0.8249	3.	Communication with the Government
	0.8136	4.	Business District Environment
actor	0.7446	12.	Communication with the Government
	0.6921	11.	Communication with the Government
	0.6791	16.	Communication with Shops
audience	0.7373	20.	Communication with Shops
	0.7232	19.	Communication with Shops
performance	0.7695	25.	Communication with Shops
	0.7599	24.	Communication with Shops
	0.7452	28.	Business District Environment
	0.7401	26.	Communication with Shops
	0.7339	22.	Business District Environment
	0.7288	23.	Business District Environment

Dramaturgyβ: "Shop and Customers"

We used Dramaturgy β: "Shop and Customers" to develop another set of questionnaires. Through these questionnaires, we found out the most important Service Elements by using Grey Relational Analysis. We extracted the 13 most important "Service Elements" to which each Shop should pay attention, sorted in order of "Grey Correlation Degree". We classified these 14 items into three ways to promote Service Quality applied in practice: Shop Environment, Promotion Strategy, and Equal Service. Moreover, "Promotion Strategy" can be divided into two sub-types: "Service Characteristics" and of "Image of the "Shop" (please see Table 4). Service Elements 34 and 40 were classified as "Shop Environment". Service Elements: 43, 59, 60, 61, 63 and 64 were classified as "Promotion Strategy". Service Elements 48, 49 and 56 were classified as "Equal Service".

Table4: Applying GRA to extract the important Service Elements from Dramaturgy β

Dramaturgical Theory	Grey Correlation Degree	Question numbers	Classification
setting,	0.8148	40.	Shop Environment
	0.7436	34.	Shop Environment
actor	0.8204	43.	Service Characteristics
	0.7746	49.	Equal Service
	0.7742	48.	Equal Service
audience	0.6735	52.	Image of the Shops
	0.6436	54.	Image of the Shops
performance	0.8254	56.	Equal Service
	0.8125	60.	Service Characteristics
	0.8024	61.	Service Characteristics
	0.7901	64.	Service Characteristics
	0.7828	59.	Service Characteristics
	0.7525	63.	Service Characteristics

DISCUSSION

Our research analyzed the "Business District Organization and Shop" questionnaires through the four dimensions of Dramaturgical Theory. Fourteen important "Service Elements" were extracted in total. Our research classified these 14 items into three ways applied in practice, enabling us to give advice to Business District Organizations. We also analyzed the "Shop and Customers" questionnaires through the four dimensions of Dramaturgical Theory. The important "Service Elements" extracted from customers were 13 items in total. Our research classified these 13 items into three ways applied in practice, enabling us to give advice to Shops. Our research contributes to promoting the Service Quality and Competitive Advantage of Business District Organizations and Shops in Taiwan.

Recommendations for Business District Organization

The main purpose of Business District Organizations is enhance the image and reputation of a given Business District, and to provide services such as communication, coordination and policy advocacy for Business District shops. The results of the questionnaire in this research suggests that Business District Organizations should emphasize14 service factors extracted from the "Shop" questionnaire, classified into three dimensions by this study: Communication with the Government, Business District Environment, and Communication with Shops. According to the order of important "Service Elements" derived from the questionnaire, we give corresponding recommendations for each important "Service Element" (please see Table 9). For the convenience of readers, the table below is based on the three ways of presenting the 14 important "Service Elements" based on questionnaire elements. It also gives corresponding recommendations for each questionnaire element.

Table9: Recommendations for Business District Organizations

Category	Question	Recommendation
Communication with the Government	1	The content of communication between Business District Organizations and governments should focus on obtaining support from local governments. For example, activities should be launched in conjunction with local government, not only to promote the Business District but also to build a young image for the city government.
	3	Business District Organizations should plan to improve transport routes, and fight for transport accessibility.
	12	Business District Organizations should seek funding for software to increase the attractiveness of the Business District's equipment.
	11	The Business District Organization should seek funding for hardware to increase the attractiveness of the Business District's architectural design.
Business District Environment,	4	Maps of the Business District should show not only featured shops, but also include notes indicating parking facilities.
	28	The Business District Organization needs to propose attractive promotional planning activities at meetings, in order to secure government grants and similar resources, and to gain the confidence of consumers.
	22	The Business District Organization must pay attention to the organization and maintenance of public facilities, enhancing communication and contact with cleaning teams to maintain tidiness in the District.
	23	The Business District Organization should maintain communication links with the police, in order to maintain the security of the Business District.

Category	Question	Recommendation
Communication with Shops.	16	The Business District Organization and its members from the various Shops should hold General Meetings regularly.
	20	The Business District Organization has a responsibility to facilitate the exchange of experience between Shops and other businesses, in addition to vertical one-way communication from the Organization. Horizontal exchanges between Shops are also important.
	19	Shops should have a supportive attitude and commit to participation in services provided by the Business District Organization.
	25	The Business District Organization should set up a means of communication, so Shops can directly convey messages to them.
	24	Real-time communication should be established between the Business District Organization and Shops. For example, establish the community of mobile application (e.g.: LINE), serve dedicated phone line.
	26	The Business District Organization should provide Shops with a means of problem resolution.

Recommendations for Shops

In the service sector, the Shop stands for the physical environment where services are provided, or the spaces where service delivery occurs (Bitner, 1990).It can be divided into two parts: "Service Delivery" means making the service available to customers, and "Service Operations" means the preparation, handling and other operations needed to enable Service Delivery. Other factors such as planning and design in "Service Operations", the atmosphere and the shop front, spatial planning, and even the attitude of personnel in "Service Delivery" will affect customer satisfaction (Lovelock, 2001).

The results of the questionnaire in this research suggest that Shopsshouldemphasize13service factors extracted from customers, grouped into the following three dimensions by this study: Shop Environment, Promotion Strategy, and Equal Service. According to the order of important "Service Elements" from the results of the questionnaire, we give corresponding recommendations for each important "Service Element" (please see Table 10). For the convenience of readers, the table below is based on the three classifications of the 13 important "Service Elements", and the questionnaire elements which refer to them. It also gives corresponding recommendations for each one.

Table10: Recommendations for Shops

Classification		Question	Recommendation
Shop Environment		40	Shops should pay attention to providing a clean shopping environment for consumers.
		34	In the Shops environment, a Shop's decorative features attract consumers.
Promotion Strategy	Service Characteristics	43	Service characteristics, such as providing after-sales services or customized service; for example, jewelry shops might add a customized service that changes piercing earrings into clip-style (folder button) earrings.
		60	The products and services offered by the Shop should be of high quality.
		61	Customers will appreciate a better quality of service from the Shop.
		64	Services provided by the Shop should make the customer feel confident.
		59	Shops should reduce waiting times. When there are queues for service in Shops, you can make waiting times less boring by providing cups, menus, books and other such items.
		63	The Shop should pay attention to providing consistent service to every guest.
	Image of the Shops	52	The Shop would more closely fit its image to the expectations of target customers through organizing activities such as charity events, music performances, etc.
		54	The Shop could invite bloggers to visit their Shops, so that bloggers could write articles based on their experience and promote the Shop to new audiences.
Equal Service		49	The Shop should provide high consistency services to consumers in two ways. Advertising must be consistent with both the actual service, and the advertised price on products. For example: the Shop should make sure that promises made in advertising and the actual products available meet customer expectations.
		48	The price of products provided by the Shop should be fair, so that consumers will buy there again.
		56	In the "marked price" section, for the Food and Beverage Service industry, the menu can be displayed at the restaurant entrance, so that customers can decide their willingness to spend before entering the Shop. For other sectors (such as clothing or bookstores) prices should be marked on the goods, so that each consumer can know that they are paying the same price as other customers.

CONCLUSION

The great majority of Business Districts around the world are like the Business Districts found in Taiwan. Our research visited the Shinshe and Yizhong St. Business Districts in Taichung, and the Ximending Business District in Taipei. We applied "Dramaturgical Theory" as a framework, and the method of analysis for our two questionnaires was "Grey Relational Analysis". We discovered the most important "Service Elements" in order of "Grey Relational Correspondence". We gave Business District Organizations recommendations for each important Service Element to promote their Service Quality, according to the 14 important Service Elements derived from Dramaturgyα: "Business District Organization and Shop". For example: Business District Organizations should try to obtain support from local governments, provide clear indications of parking facilities on maps of the Business District, and hold General Meetings for the Business District Organization and its member Shops regularly. We gave Shops recommendations for each important "Service Element" to promote their Service Quality, according to the 13important Service Elements from Dramaturgy β: "Shop and Customer". For example: Shops should provide a clean shopping environment for customers; they should provide after-sales services or customized services; and customers should receive a high consistency of service. The results of our research can be applied to Shops in other countries to promote their Service Quality.

REFERENCES

1. Cathy H. C. Hsu, Tom Powers (2002), Marketing Hospitality, 3rd Edition, Handbook, John Wiley and Sons.
2. Donald Getz (1993), Planning for Tourism Business Districts, Annals of tourism research, 20, pp. 583-600.
3. Grove, S.J., R.P. Fisk and M.J. Bitner (1992), Dramatizing the Service Experience: A Managerial Approach, Advances in Services Marketing and Management, 1, pp. 91-121.
4. Guiry, M. (1992), Consumer and Employee Roles in Service Encounters, Advances in Consumer Research, 19(1), pp. 666-672.
5. Ghosh, A. (1994), Retail Management (2nd ed.), NY: The Dryden Press
6. Huff, D.L. (1964), Defining and Estimating a Trading Area, Journal of Marketing, 28(3), 34-38.
7. Lovelock, H.C. (2001), Service Marketing: People, Technology, Strategy, NJ: Prentice Hall.
8. Leon G. Schiffman, Håvard Hansen, Leslie Lazar Kanuk (2008), Consumer Behaviour: A European Outlook, Prentice Hall/Financial Times.
9. Meltzer R. (2012), Understanding Business Improvement District formation: An analysis of neighborhoods and boundaries, Journal of Urban Economics, 71, pp. 66-78.

10. Mary Jo Bitner (1992), Servicescapes: the impact of physical surroundings on customers and employees, The Journal of Marketing, 56, 57-71.
11. M.M. Maye, J. Luo, Y. Lin, M.H. Engelhard, M. Hepel, C.J. Zhong, Langmuir, 2003,19, 125.
12. Parasuraman, A., V.A. Zeithaml and L.L. Berry (1985), A Conceptual Model of Service Quality and Its Implications for Future Research, Journal of Retailing, 64(1), pp. 12-40.
13. Priskin, J. (2001). Assessment of natural resources for nature-based tourism: the case of the Central Coast Region of Western Australia. Tourism Management, 22 (6): 637–648.
14. Parasuraman, A., V.A. Zeithaml and L.L. Berry (1985), A Conceptual Model of Service Quality and Its Implications for Future Research, Journal of Retailing, 64(1), pp. 12-40.
15. Stoke, J.A., Dahal, L.R., Jian Li, Podraza, N.J.(2008),Optimization of Si: H multijunction-i-p solar cells through the development of deposition phase diagrams, pp.1-6.
16. Chao-Ho Wang (2008). The Critical Success Factors for Chia Hsien Image Commercial District，Master's Thesis of Department of Travel and Tourism Management.
17. Ching-Sung Lee, Chih-Yen Huang, Chun-Fu Yu (2010)，A Study on the Key Success Factors of the Business Districts in Taiwan，Management practices and theoretical research，4(4)，p.p. 65-81.
18. Tzong-Ru Lee, Shing-Chi Chang(2006)，The Feasibility Study of Selling Agricultural Products in the Business Circle of High Speed Train Stations，Chinese Journal of Agribusiness Management, No.12, p.p.1-26.
19. Bo-Shou Lin, Han-Chieh Tsai, Chen-Yu Chen, Wen-Chun Lo(2008)，A Study on the Standard Operation Process of Instant Field Investigation，Journal of Soil and Water Conservation Technology，3(3)，p.p.147-187.
20. Kuo, Wei-Chi（2001），A Study of the Key Factors for Site Environment of the Impression Trading Area in the Country Region，Master's thesis of Department of Architecture, National Taiwan University Institute of Science and Technology.
21. Wan-Ling Hsu (2005). An Empirical Study on Relationship Among Trade Area Feature, Store Managerial Strategy and Customer Satisfaction-For the Example of Department Store Trade Area，Providence University Institute of Business Administration Thesis.
22. Ju-Long Deng (1989). Multidimensional Grey Planning，Huazhong University Press.
23. Chia-Chun Lai, Li-Ming Ho (2005). An Exploration of Operations Performance and Customer satisfaction of Image Business Cluster in Central Taiwan, Journal of National United University, 1, p.p.24-42。

IMPLEMENTING BALANCED SCORECARD IN A SUBSIDIARY ORGANIZATION IN HIGH TECHNOLOGY INDUSTRY

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ABSTRACT

Purpose: Under the contemporary economic environment with severe international competitions, high-tech industry relies heavily on its operation and research and development abilities to pursue the maximum profit and shareholder value with the minimum operation expense. The competence of a company is ensured by how it measures its operation performance, and how it internalizes the measure in accordance with its development strategy and operation guideline. Financial performance is a crucial indicator of the past operation strategy of a company. However, for a company to sustain and continuously grow, evaluation of its non-financial performance is indispensable. Thus, by taking both short-term and long-term growth drivers into consideration, we proposed using balanced scorecard (BSC) for a company or organization to carry out its strategy and evaluate its performance.

Design/methodology/approach: Following the principle of BSC, strategic objectives from the four perspectives are defined in accordance with company strategy; and, they are causally linked to form the strategic map to ensure the synergy of these objectives. The key performance indicators according to the strategic objectives from the four perspectives of BSC are then properly defined and quantified.

Findings: Our proposed approach has been implemented in an R&D Lab of a company, specializing in assembling high-tech products and providing technical services, for more than four months. Though it takes some more time for some lag indicators to have their first evaluation, the approach receives high appreciation for its practical applicability from the members of the Lab and the board of management of the company.

Originality/Value: Our approach can serve as a good reference for similar organizations to construct their own performance management system.

Keywords: Balanced scorecard, Organization strategy, Performance indicator

INTRODUCTION

Nowadays, in a fierce competition marketplace, every business organization has to be competitive to maintain and increase profits. They need to establish proper system to measure its operation performance, and internalize the measure in accordance with their development strategy and operation guideline. Conventional performance measures focus only on the financial aspect (Fisher, 1992; Kaplan and Norton, 1992; Kaplan and Norton, 1996a; Atkinson et al., 1997; Griffiths, 2003). This is an intuitive approach because making profit is critical to the survival and growth of any company. However, the financial index is only a post measure of an operation strategy. It apparently neglects customer need, employee centripetal force, and cooperation of inner processes, which altogether contribute significantly to the sustainable management and profit making. In addition to short-term profit, it is also crucial for a company to improve its long-term competitiveness (Butler *et al.*, 1997). As such, the inclusion of non-financial indices allows a company to be aware more of its future visions (Eccles and Pyburn, 1992).

Hence, in recent years, several industries have been aggressively seeking for performance evaluation systems that combine financial and non-financial indices. Among these, the balanced scorecard (BSC) proposed by Kaplan and Norton (1992) is the most well-known as a holistic system of performance measure with four perspectives, including finance, customer, internal process, and innovation and learning which directly link to organization vision, value, and mission (Kaplan and Norton, 1996a; 1996c). With performance indices from different perspectives, BSC is able to evaluate both financial and non-financial performances of an organization in both macroscopic and microscopic perspectives in a systematic manner; hence, it constructs a part of the knowledge management architecture. To use BSC, it is necessary to properly select KPIs from the four perspectives mentioned above.

To date, most applied research of BSC aims at profit or non-profit organizations. There are only a few about the subsidiary organizations in a company. As a matter of fact, a company actually the integrates all of its subsidiary organizations, implying that the company would fail its defined strategy if its subsidiary organizations could not execute given tasks effectively. As such, this study proposes using the BSC to construct a performance evaluation system for a subsidiary organization with specific functions and orientation in a company specialized in assembling high-tech products and providing technical services. This approach can be a good reference in constructing the performance evaluation system for other organization with similar functions.

LITERATURE REVIEW

BSC was proposed by Kaplan and Norton (1992) who claimed that conventional financial performance indicators cannot help achieve the goal of sustainable management and profit. Instead, if non-financial performance indicators are included, visible and invisible assets of a company can be combined with company vision and strategy to drive the growth of the company (Kaplan and Norton, 1996b). If companies focus on financial indicators only, they will only look at short-term profit rather than long-term profit, emphasize result rather than process, strive in reducing cost without considering overall company benefit (Lee, 1987; Kaplan and Norton, 1996b; Kaplan and Norton, 2001; Niven, 2002), and as a result, lose the decisive information and application to adapt to market change (Eccles and Pyburn, 1992; Hoffecker and Goldenburg, 1994).

Furthermore, companies may hesitate to invest in invisible assets which create future value (Itter and Larcker, 1998) or decrease the quality to exploit customers (Kaplan and Norton, 1996b). The more emphasis laid on innovation by a company, the more non-financial performance indicators will be used (Itter and Larcker, 1998). Also, a survey on company operation shows that non-financial performance indicators do help improve organizational performance (Davis and Albright, 2004). However, non-financial performance indicators are rather abstract and difficult to be quantified, which leads to the difficulty in practical application even though it is well recognized that non-financial performance indicators are crucial to company operation and development. That is why there is a great gap between cognition and reality in adopting non-financial indicators (Fisher, 1992; Stivers *et al.*, 1998).

According to the above discussion, with four key perspectives, including financial, customer, internal process, and learning and innovation, BSC is a favourable tool in the performance management because when a reward and punishment system is linked with the performance indicators, development goals of an individual employee are accordingly adjusted towards those of the organization. Nonetheless, how to turn company strategy into appropriate performance indicators is still an important issue in the application of BSC.

A PRACTICAL APPLICATION

The subject of this study is the R&D Lab (hereinafter called *"the Lab"* for brevity)of a company in Taiwan. Its main business is semiconductor assembly and test services (SATS) with the global market share of about 15%. The Lab is in charge of the planning, research, and development of next generation packaging technologies. Besides R&D projects and basic scientific research, the Lab is also in charge of technical services for internal and external clients with an annual monetary value of more than USD2 million (Lai, 2008; 2010). The technical services provided by the Lab are extremely diversified, covering tests and numerical modelling of electronic packaging related mechanical and reliability, thermal, and material characteristics, along with corresponding sample preparations and failure analyses.

With the mission of providing world leading technical services in SATS, the strategic objectives from the four perspectives of BSC are suggested in Figure 1. Figure 2 shows the causal relationship of strategic objectives from the four perspectives for technical services in the Lab. The perspectives are found positively correlated. According to the BSC for technical services in the Lab in Figure 1, corresponding performance indicators from the four perspectives are listed in Table 1. It is worth noting that these BSC performance indicators were set to meet the peculiar organization functions and tasks of the Lab. Performance indicators for individual employees have to be set in accordance with the organizational performance indicators, avoiding the confusion between organization and employee performance.

Financial	Customer
Increase in monetaty value Decrease in operation cost	Meeting customer needs Improvement of service quality Creating win-win situation
BALANCED SCORECARD	
Internal Process	Learning and Innovation
Enhancement of operation efficiency Decrease in human error Uniquely new technical service provision	Expansion of technology Improvement of patent quality and quantity Continuous learning of new knowledge

Fig.1: BSC for technical services in R&D Lab

Performance Indicators from Financial Perspective
According to the Lab, the financial perspective stands for the monetary value of provided technical services, and the income from technical services is actually a part of the company revenue. Generally, financial performance indicators reflect the previous operation strategy. Because execution efficiency of technical services and equipment utilization are similar to the capacity utilization in the factory production line, financial indicators include the monetary value of provided technical services, execution efficiency of the technical services, and equipment utilization which are described as the following.

➢ *Monetary value of technical services:* Monetary value of technical services stands for the sum of actual income generated by providing technical services and the waived or discounted payment in response to company customer strategy. Though intuitively the total number of technical service cases can be used as a performance indicator, it is unable to distinguish complicated cases from straightforward ones, and thus unable to distinguish between heavy and light work duties or values from different technical services. Therefore, it is more reasonable to use the charge price of a technical service, defined based on the presumed employee work hours and equipment depreciation, to calculate the grand monetary value of provided technical services, and use it as part of

the performance evaluation. The monetary value of provided technical services is targeted to increase by 5% every year. Intuitively, this can be achieved by enhancing operation capacity by expanding equipment and human resources, by introducing new technical services, by introducing new customers, by increasing the number of technical service cases through lowering down the charge prices, or by adding up the monetary value through increasing the charge prices of technical services. As the main function of the Lab is to provide technical services to satisfy customers in hope to get more SATS orders from the customers, sometimes the technical services are offered free of charge to important or potential customers in strategic considerations. As a result, only monetary value is targeted for performance evaluation of the technical services. The actual income is recorded for reference only.

➢ *Execution efficiency of technical services:* As the Lab plays multiple roles in conducting R&D projects, basic scientific research, and technical services, most of the Lab members are more or less assigned with tasks in all these three categories at the same time. A dynamic performance evaluation of technical services was proposed by Shu *et al.* (2013) and has been successfully used in practice.

➢ *Equipment utilization:* Calculation of equipment utilization is similar to the calculation of total work hours of technical services. The difference is that equipment utilization is based only on the actual schedule. As profit making is not the target of the Lab, equipment utilization in this sense cannot be regarded as capacity utilization in the factory production line. Instead, the purpose to monitor equipment utilization in the Lab is to evaluate whether to purchase, eliminate, or transfer equipment in response to insufficient capacity or overcapacity, and to understand how feasible the equipment is. While certain equipment is under maintenance, related technical services have to be suspended during the period. Also, some equipment is used in part to support R&D projects and basic scientific research. Hence if insufficient capacity or overcapacity of the equipment is to be monitored, the performance goal in the Lab for the utilization of specific equipment in technical services can be set to 25~75% of its theoretical utilization hours. For automatically operating equipment, it is targeted to be used for not more than 18 hours and not less than six hours per day. The equipment utilization rate is recorded every day and evaluated every six months. If the use of specific equipment in the past six months is generally higher or lower than its utilization target, whether to purchased, eliminated, or transferred the equipment should be considered.

Lead indicators from the financial perspective is the ratio of total monetary value of technical services over operation cost, and the goal is to make operation cost no more than total monetary value of technical services. The ratio is calculated for a specific month and is also calculated as a cumulative from the beginning of the year. Lead indicators represent the incentives to achieve performance goals. This ratio is conducive to the department and

organization management in adjusting the operation every month to meet the annual financial goal.
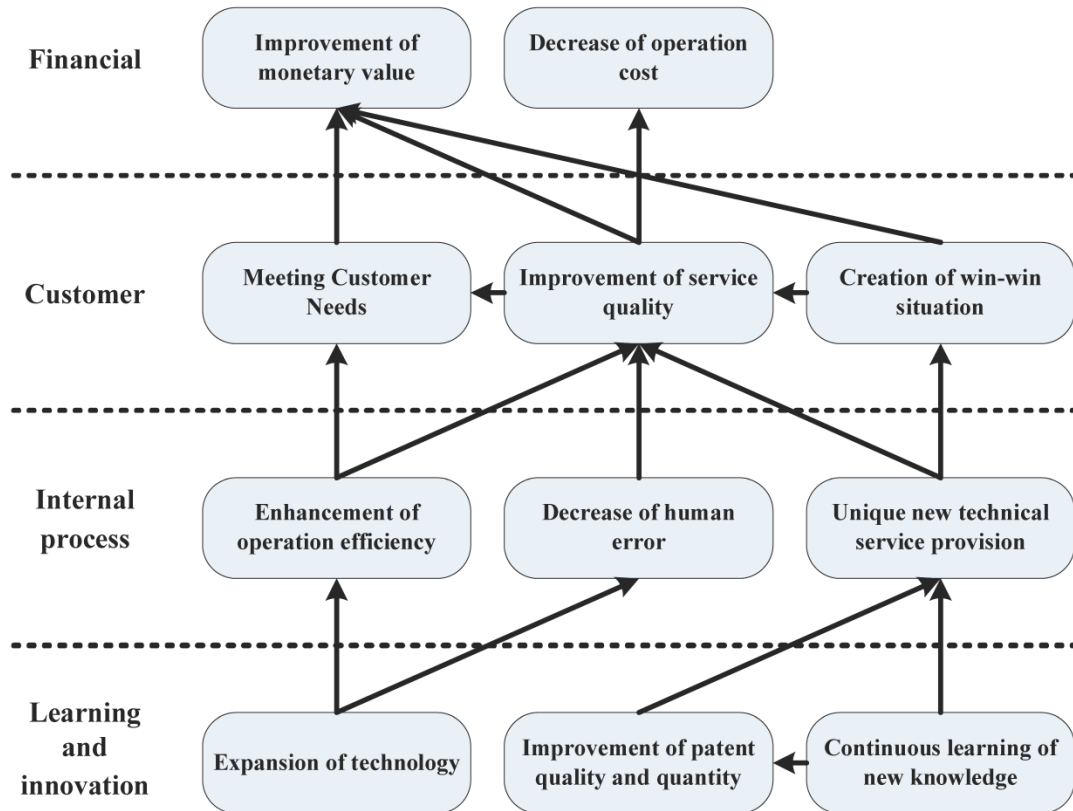
Fig.2: Causal relationship among the BSC objectives for technical services

Performance Indicators from Customer Perspective

As the Lab does not aim at profit making, its customers are actually those of the company. Kaplan and Norton (1996a) claimed that market and customer share, customer growth, customer retention, customer satisfaction, and customer profit are the five core measures from the customer perspectives. However, these five core measures cannot generally be applied to the Lab owing to its specified function and position. Particularly, market share is not the main focus of the Lab; and, customer growth depends on the company operation

Table 1: BSC performance indicators for technical services in R&D Lab

Strategic objectives	Measure		Target and frequency for performance evaluation
	Lead indicators	Lag indicators	
Financial • Increase of monetary value • Decrease of operation cost	Ratio of monetary value over operation cost	• Monetary value • Execution efficiency • Equipment utilization	• Annual ratio of monetary value over operation cost > 1 (monitored per month) • Monetary value increases by 5% per year • Work hour ratio: actual over planned ≥ 1 (monitored per week) • Equipment utilization ratio: actual over planned in the range between 25 to 75% (monitored semiannually)
Customer • Meeting customer needs • Improvement of service quality • Creation of a win-win situation	• Number of co-development cases • Number of consulting cases	• Customer satisfaction • Number of major customer complaints • Customer retention rate	• Counting co-development and consulting cases as additional performance (summarized semiannually) • Customer satisfaction > 90% (monitored semiannually) • No major customer complaint (summarized per month) • Customer retention > 90% (monitored per year)
Internal process • Enhancement of operation efficiency • Decrease of human error • Unique new technical service provision	• On-time delivery rate • Achievement rate of existing service improvement • Achievement rate of new service introduction	• Obedience of standard operation procedure (SOP) • Correctness of technical reports	• Delivery ratio of non-delayed cases > 90% (monitored per month) • On-time delivery of existing service improvement (evaluated semiannually) • On-time delivery of new service introduction 9evaluated semiannually) • SOP auditing in an irregular basis • Zero mistake in technical reports (summarized semiannually)
Learning and innovation • Expansion of technology • Improvement of quality and quantity of patents • Continuous learning of new knowledge	• Number of technical service certificates • Number of patent and trades secret proposals approved internally • Participation rate of on job training (OJT)	• Retention rate of high quality employees • Number of rewards	• Achievement of planned technical service certificates to acquire (summarized semiannually) • Achievement of the planned number of patents (summarized semiannually) • OJT participation rate > 90% (monitored semiannually) • Retention rate of top 50% employees > 80% (evaluated semiannually) • Counting external or internal rewards as additional performance (summarized semiannually

strategy, as well as customer profit is difficult to measure through technical service provision. Only customer retention and customer satisfaction can be used as the performance measure of the Lab. Besides the operation advantage (price advantage) led by waived or discounted charges of technical services for some strategically important customers defined by the company strategy, the Lab, with qualified members and rather complete equipment, is capable of providing customers with additional value, such as consulting services and cooperating with customers to develop new technologies or products specifically for customer needs. The Lab can hence differentiate with competitors in customer relation through customized services and long-term cooperation as well as product advantage through developing key products or technologies.

Lead indicators from the customer perspective for the technical services in the Lab include number of co-development cases with customers and the number of consulting cases. As these two are not regular services, their performance evaluation standards are not easy to define. Hence they should be recorded and reviewed every six months and serve as an additional performance of employees and organization. Lag indicators from the customer perspective are customer satisfaction, the number of major customer complaints, and customer retention rate, described respectively as the following.

➤ *Customer satisfaction:* The standard operation procedure (SOP) of a technical service in The Lab specifies that upon the delivery of the technical report after completion of the service, a customer is given a chance to feedback to management department with the satisfaction survey. The performance indicator is set such that more than 90% of the technical services are satisfactory, and this is reviewed every 6 months.

➤ *Number of major customer complaints:* Compensation and loss of customers usually come along with a major customer complaint, which jeopardizes long-term relationship with customers. In the investigated company, an electronic information system recording major customer complaints with corresponding improvement tracking has already been established. Therefore, major customer complaints related to the technical services can be extracted from this information system. The performance target is set such that no major customer complaint is allowed, and this is reviewed monthly.

➤ *Customer retention rate:* Customer retention actually depends on the business development strategy of the company. According to the previous experience, in about three to five years, those top big customers shall remain, and these customers also represent the majority to receive technical services from the Lab. The customer retention rate of the Lab is therefore not about to change in at least several years. Taking the actual situation into account, the customer retention rate is set to maintain more than 90% of the present customers annually.

Performance Indicators from Internal Process Perspective

From the causal relationship of the BSC strategic objectives for technical services in the Lab, as shown in Figure 2, for process innovation, the 'unique new technical service provision' from the internal process perspective directly relates to 'cooperation with customers for a win-win situation' from the customer perspective. As there are extensive activities involved in R&D projects and basic scientific research in the Lab, high quality employees and top notch equipment are well prepared for process innovation. Moreover, the 'enhancement of operation efficiency' and 'decrease of human error' from the internal process perspective are involved with the operations cycle while the post-sale service cycle involves the consulting services from the customer perspective.

Lead indicators from the internal process perspective for the technical services in the Lab are on-time delivery rate of technical services, achievement rate of existing service improvement, and achievement rate of new service introduction, which are explained below.

➢ *On-time delivery rate of technical services:* In the actual operation in the Lab, supervisor in charge of management of technical services in each lab assigns start and delivery dates for each technical service and the responsible staff. The assignment is usually done based on the consideration of the current workload as well as special customer needs in some cases. There is no systematic way to do the assignment yet. In an ideal case, the planned and actual execution period of a technical service should be identical, i.e., the planned and actual start/delivery dates should be consistent. As there are sometimes uncertainties such as the emergent cases from customers that need to be handled at top priority, the ideal situation is in general difficult to maintain in operation. Nevertheless, early start, late start, or early delivery of the technical services does not generally lead to the unsatisfactory of customers except late delivery. Therefore, on-time delivery rate of technical services, defined by the ratio of non-delayed cases over the total delivered technical services in a specific time period, plays an important role in making customers satisfied. The ratio is targeted at more than 90% and is evaluated monthly.

➢ *Achievement rates of existing service improvement and new service introduction:* Semiconductor technology development roadmaps are published in a regular basis by several industry standardization organizations, such as International Technology Roadmap for Semiconductors (ITRS) and International Electronics Manufacturing Initiative (iNEMI). These roadmaps consider the overall trends in technology development and demands in semiconductors and final electronic products. The technology development roadmap of the Lab can, therefore, be defined after analysing and integrating the trends reported by these standardization organizations. Whether an existing technical service needs to be amended or whether a new technical service needs to be established can then be identified from the gap between existing and demanded technologies shown on the roadmaps. Since it may take long time to improve or establish technical services, it is more feasible for the achievement rate to serve as a status

performance indicator. The achievement rate is reviewed in every six months to check whether the set milestones are accomplished.

Lag indicators from the internal process perspective include obedience of SOP and correctness of technical reports. The SOPs for all technical services have been specified in the Lab. There should be irregular auditing to make sure that the employees correctly follow the SOPs in order to maintain work discipline and ensure the consistency and liability of technical services. The technical report delivered to customer after completion of a technical service should be accurate. Practically, the technical report is compiled by a responsible staff assigned for the technical service, and is approved by an authorized supervisor and department manager prior to its delivery to customer. Mistakes found during approval and through feedback from customer are recorded. The SOP auditing results and mistakes in technical reports are reviewed every six months and they serve as part of the semi-annual employee performance evaluation.

Performance Indicators from Learning and Innovation Perspective

Learning and innovation perspective is crucial for a company to maintain business continuity. Technical ability and creativity of employees enable the organization to sustain and thrive. To cultivate technical ability and creativity of employees, the learning and innovation perspective includes three strategic objectives: expansion of technology, improvement of quality and quantity of patents, and continuous learning of new technology. Besides, there are three lead indicators in this perspective, including the number of technical service certificates, the number of patent and trade secret proposals approved internally, and participation rate of on job training (OJT).

➤ *The number of technical service certificates:* After a careful evaluation and benchmarking, the capability of each employee in performing technical services can be categorized, ranked, and compiled into an organization capability chart, which reflects the present human resources for technical service assignment. To make the assignment of a technical service more flexible, it is crucial to have employees trained continuously to handle a broader spectrum of technical services. Continuous expansion of the technical ability of an employee is definitely beneficial to the development of both the employee and organization. The certification of a technical ability begins with certain hours of lectures and guided practices, followed by written exams and monitored operation. The number of technical service certificates that an employee needs to obtain is defined in the semi-annual performance target setting through an agreement between the supervisor and employee. The result is examined semi-annually.

➤ *The number of patents and trade secret proposals approved internally:* Patents are important protection for a company to operate, develop, and expand market. Patent proposals represent technical innovation ability and creativity of employees. However, with the application and maintenance fee soaring, patent application would become more

conservative, focusing on better quality. Typically, it takes one to several years for a patent to be certified by the government intellectual property agent after its application. As such, the number of patents is not feasible to serve as a performance indicator due to its lack of timeliness. A more appropriate performance indicator is the internal approval of the proposal, either patent or trade secret, by the intellectual property department inside the company, which takes around several weeks for the decision to be made. The number of patent and trade secret proposals approved internally is evaluated every six months.

➢ **Participation rate of OJT:** The OJT helps employees be aware of and familiar with business culture, enhance technical ability, and develop towards a diverse career. In addition to OJT held by the company, the Lab also holds seminars and technology presentations regularly. The participation rate of OJT is targeted at an attendance of 90% of the obligatory courses or activities assigned to an employee. It is reviewed every six months.

Lag indicators from the learning and innovation perspective include retention rate of high quality employees and number of internal and external rewards. With limited resources, elimination of unqualified employees is the reality for an organization to effectively reach its strategic target. Therefore, the retention rate should only take high quality employees into account. The retention rate is targeted at annually more than 80% of the employees with top 50% performance stay in the organization. The number of internal and external rewards received by an employee or a group of employees are recorded and examined every six months to serve as an additional performance.

Our proposed approach has been implemented in the Lab for more than four months. Though it takes some more time for some lag indicators to have their first evaluation, the approach receives high appreciation for its practical applicability from the members of the Lab and the board of management of the company. Further analysis should be made after the entire lag indicators meet the specified periods.

CONCLUSION

In this paper, following the principle of BSC and through a careful organizational analysis of R&D Lab in a company which specializes in assembling high-tech products and providing technical services in a high technology industry, adequate strategic objectives, strategic map, and KPIs for the R&D Lab in conducting technical services are proposed from the financial, customer, internal process, and learning and innovation perspectives. The causal chain of the strategic objectives is established to form the strategic map so that the synergy of BSC is ensured, allowing the R&D Lab to achieve its final goal of continuously being a world leading technical service provider in SATS. Corresponding to the strategic objectives from the four perspectives, the KPIs, separated in lead and lag indicators, are carefully selected,

quantified, and each set with a performance target and an appropriate evaluation period. Through the performance management system thus established, while evaluating short-term financial performance of the R&D Lab, evaluation of non-financial performance indicators is also included to cope with the long-term needs for its organization development. Also, this paper demonstrates how BSC, as a tool in carrying out strategy and evaluating performance, can be implemented to a subsidiary organization. Our proposed approach serves as a good reference for similar organizations to construct their own performance management systems.

REFERENCES

1. Atkinson, A.A., Balakrishnan, R., Booth, P., Cole, J. M., Groot, T., Malmi, T., Roberts, H., Uliana, E., and Wu, A. (1997), "New directions in management accounting research", *Journal of Management Accounting Research*, Vol. 9, pp. 79-108.

2. Butler, A., Letza, S.R., and Neale, B. (1997), "Linking the BSC to strategy", *Long Range Planning*, Vol. 30 No. 2, pp. 242-253.

3. Davis, S., and Albright, T. (2004), "An investigation of the effect of BSC implementation on financial performance", *Management Accounting Research*, Vol. 15 No. 2, pp. 135-153.

4. Eccles, R.B., and Pyburn, P.J. (1992), "Creating a comprehensive system to measure performance", *Management Accounting*, Vol. 74 No. 4, pp. 41-44.

5. Fisher, J. (1992), "Use of performance measures", *Japanese Cost Management*, Vol. 6 No. 1, pp. 31-38.

6. Griffiths, J. (2003), "BSC used in New Zealand government departments and crown entities", *Australian Journal of Public Administration*, Vol. 62 No. 4, pp. 70-79.

7. Hoffecker, J., and Goldenburg, C. (1994), "Using the BSC to develop company-wide performance measures", *Journal of Cost Management*, Vol. 8 No. 3, pp. 5-17.

8. Itter, C.D., and Larcker, D.F. (1998), "Innovations in performance measurement: trends and research implications", *Journal of Management Accounting Research*, Vol. 10, pp. 205-238.

9. Kaplan, R.S., and Norton, D.P. (1992), "The BSC – measures that drive performance", *Harvard Business Review*, pp. 71-79.

10. Kaplan, R.S., and Norton, D.P. (1996a), *The Balanced Scorecard: Translating Strategy into Action*, Harvard Business School Press, Boston, MA, USA.

11. Kaplan, R.S., and Norton, D.P. (1996b), "Using the BSC as a strategic management system", *Harvard Business Review*, pp. 3-13.

12. Kaplan, R.S., and Norton, D.P. (1996c), "Linking the BSC to strategy", *California Management Review*, Vol. 39 No. 1, pp. 53-79.

13. Kaplan, R.S., and Norton, D.P. (2001), *The Strategy Focused Organization*, Harvard Business School Press, Boston, MA, USA.

14. Lai, Y.S. (2008), "ASE Central Labs overview", *ASE Technology Journal*, Vol. 1 No. 1, pp. 2-6.

15. Lai, Y.S. (2010), "Journal publications by ASE Central Product Solutions as of May, 2010", *ASE Technology Journal*, Vol. 3 No. 1, pp. 93-98.

16. Lee, J.Y. (1987), *Management Accounting Changes for the 1990s*, McKay Business Systems, Artesia, CA, USA.

17. Niven, P.R. (2002), *BSC Step-by-Step: Maximizing Performance and Maintaining Results*, John Wiley & Sons, New York, NY, USA.

18. Shu, M.H., Kung, J.Y., Nguyen, T.L., and Hsu, B.M. (2013), "Dynamically monitoring the service efficiency with tracking signals", *Industrial Management & Data Systems*, Vol. 113 No. 9, pp. 1334-1350.

19. Stivers, B.T., Covin, T.J., Green, N., and Smalt, S. (1998), "How nonfinancial performance measures are used", *Management Accounting*, Vol. 79 No. 8, pp. 44-49.

THE EFFECT OF TOURISM DEVELOPMENT ON LOCAL INDUSTRY'S ECONOMIC BENEFITS BASED ON THE CONTINGENT VALUATION METHOD - A CASE STUDY OF THE LIUQIU SCENIC AREA

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ABSTRACT

Purpose: *Based on the contingent valuation method (CVM), this research studied the economic benefits of tourism activities in Liuqiu scenic area through the different viewpoints of visitors and inhabitants.*

Design/methodology/approach: *In the aspect of visitors, models such as Probit and Logit were established for evaluation while Willingness to Pay (WTP) was used as measurement. Regarding the inhabitants part which adopted Willingness to Work (WTW) as WTP, the research conducted regression models like Probit and OLS (Ordinary Least Squares) for model evaluation and verification.*

Findings: *After analyzing the difference among various models based on evaluation results, the research results showed that (1) When WTP and WTW were used to estimate visitors and inhabitants' WTP, they all equipped with excellent explanations, regardless of the model options in Probit, Logit or OL; (2) Compared to the visitors' WTP, the research found the inhabitants' WTW showed smaller difference between evaluation result and average number; (3) According to the cumulative distribution or the character of cumulative-function distribution from the interviewed inhabitants' data, the research found WTW reflects more*

inhabitants' viewpoints than WTP; and (4) WTW can accordingly represent inhabitants' WTP.
Originality/Value: *In the previous researches, WTP is usually represented by currency. However, this research attempted at using WTW as an alternative CVM option to measure the WTP. By comparing the difference between inhabitants' WTP and WTW, this study found that the distribution trend of WTW shows more even from its sampling distribution. Meaning that inhabitants show the more consistency on the WTW.*

Keywords: Contingent valuation method, Economic benefit, Liuqiu scenic area

INTRODUCTION

The Liuqiu Township is an important island administrative region of PingTung County. With 6,801 km^2 and 13,000 inhabitants, this island is famous for its outstanding tourism and recreation resources. It was oriented for "Liuqiu scenic area" by the Ministry of the Interior, and later delimited to the scope of business management under Dapeng Bay National Scenic Area in May, 2000.

Unlike general goods measured by concrete market price, the benefit evaluation of tourism development on local industry must be estimated by non-market evaluation technique. The commonly used methods are Hedonic Price Method (HPM), Contingent Valuation Method (CVM) and Travel Cost Method (TCM). Compared to the others, the CVM is superior in its unrestricted application range and objects.

On the basis of viewpoints from inhabitants and visitors inside or nearby the Liuqiu scenic area, this research established the evaluation model to measure the user benefit (inhabitants and visitors) based on CVM. Besides, In order to achieve the objective evaluation on the value, the research also reflected scenic-area value by using users' economic benefits. The purposes of this research were as follows: (1) Establish the evaluation structure of economic benefit in scenic-area by CVM; (2) Model the WTP evaluation through viewpoints from visitors and inhabitants; meanwhile, seek the suitable evaluation methods based on model differences comparison; (3) Specify the concrete WTP of visitors and inhabitants on scenic-area visits by proper payment method (WTP and WTW); (4) Acquire the utility from visitors and inhabitants after their scenic-area visits by deducing their WTP. As a result, this user benefit represents the economic benefit of the scenic area.

LITERATURE REVIEW

The definition of contingent valuation method

The contingent valuation method (CVM) takes the questionnaire survey to inquire interviewees for their willingness to pay (WTP) or willingness to accept (WTA) by the increase of environment and resources supply or the improvement of environment quality. The empirical concept of CVM was first proposed by Ciriacy-Wantrup (1942). Later, it was first applied on the plan of Maine forest recreation resources by Davis (1963).

Research and application of contingent valuation method

The research of non-market goods economic evaluation has drawn much attention in western countries. The study found that CVM has been widely applied on measuring recreation benefits. For instance, Huang (1990) used two different methods- TCM (Travel Cost Method) and CVM to investigate the recreation benefits of four national parks, and then compare their empirical results. Regarding the estimated value of recreation benefits, his results indicated that value estimated by CVM is obviously lower than TCM.

With the exception of applying CVM to estimate recreation benefits, there are still numerous researches using various models to compare and analyze the difference. Taking the research of Li *et al.* (2002) for example, they used CVM and TCM methods to estimate the consumer surplus and WTP reflected in the three models- OLS, Probit and Logit separately. According to the analysis result, the value in TCM is higher than the one in CVM, therefore, it can be inferred that it shows degradation phenomenon in environment of cultural property.

RESEARCH METHOD

Research subject

During the discussion on user benefit in the park, both visitors and inhabitants around the park should be included it not only needs to included. Given that the convenience and effectiveness during the investigation, this research focused on visitors and inhabitants in the park as subjects.

Questionnaire design

Evaluating the effect that environment changes brought to people's WTP, the result of WTP varies due to the different residential distance of interviewees. It can be measured the visitors' WTP by travel cost; however, the situation of WTP value might be zero for the inhabitants of the park. Traditionally, WTP is usually represented by currency. To effectively

measure the different WTP between visitors and inhabitants as well as avoid any potential bias caused by questionnaires, this research attempted to study inhabitants' WTP by using different WTP types. Moreover, it also selected the willing to pay the work (WTW) to present the same evaluation effectiveness as the existing payment method of WTP.

The research evaluation was conducted through two main aspects: (1) Visitors' tourism activities in Liuqiu scenic area; (2) Inhabitants' viewpoints of environment maintenance around the Liuqiu scenic area. According to the interviewees' various preference on scenic area, the research investigated the utility differences between inhabitants and visitors. Furthermore, it studied the interviewees' different attentions on scenic area via the difference of WTP from inhabitants and visitors. Eventually, measured the economic benefit of scenic area based on the WTP between visitors and inhabitants.

Data Analysis

The statistical analysis tool used in this research is computer statistical software SPSS 18.0. The methods of statistical analysis for this study are as follows:

Descriptive statistics

Descriptive statistics is mainly to simplify the complexity during data analysis. For instance, frequency distribution, rates, mean and standard deviation, etc., these can be used to comprehend the distribution of basic information.

Regression

As an extending application of simple correlation, multiple regression analysis is applied to understand the linear relationship between a set of predictor variables (independent variables) and a criterion variable (dependent variable). After setting WTP as dependent variable, this research consequently explored the relationship between other variables (i.e. visitors' experience, personal view; whether they know, whether they approve, what impress them; visitors' gender, age) and WTP. Besides, regression models such as Logit and Probit were all used for analysis during the research.

THE EMPIRICAL RESULT ANALYSIS

Model construction of utility evaluation for visitor's usage in Liuqiu scenic area

To establish the visitors' utility evaluation model, this research adopted Logit and Probit models. Meanwhile, it also defined each variable of models in advance (see Table 1) during the empirical analysis. Several factors influenced users' WTP, including users' social

background, tourism characteristics, attitude and cognition towards recreation sites, etc. Besides, it selected factors (independent variables) affecting WTP in scenic area based on questionnaire content, namely the 10 factors shown in Table 2. The definition of variables, content and expected symbols are illustrated below.

Table 1. Factors influencing users' WTP

Item	Influence factor	
User's Socio-economic background	• Gender	• Age
	• Educational background	• Personal income
	• Family income	• Number of tourists
	• Marital status	• Personal expense on recreation and entertainment per month
	• Underage population (18 years old below)	
User's tourism characteristics	• Frequency of visit	• Transportation time
	• Transportation fee	• Duration of stay
Attitude and cognition towards recreation sites	• The cognition towards ecotourism, environmental protection and environmental impact	
	• The cognition of recreation attitude	
	• Recreation motivation and behavioral variable	
	• Willingness to join low-season activities	
	• Landscape preference	
Others	• Pollution	• Ticket price in recreation area

Table 2. Definition of explanatory variable and expected symbols in the empirical model

Variable	Symbol	Variable definition	Expected symbol
Visitor's visit times in City i	V_i	Visitor's visit times for recreation area in City i (Unit: time).	Uncertainty
Whether they know	$KNOW_i$	Whether visitor know recreation area in City i (Known marked as 1, unknown marked as 0).	+
Recreation importance	$RIMP_i$	The chosen City i trip shows its importance	+
Visitor's travel cost for his/her	TC_i	Visitor's travel cost for his/her visit in	+

Variable	Symbol	Variable definition	Expected symbol
visit in City i		City i (Unit: NTD).	
Whether to increase travel times	INC_i	After visit, will visitor increase their visit times here in the future? (Yes marked as 1, No marked as 0).	+
Casual visit or special trip	$TYPE_i$	Is visitor's trip type for recreation area in City i? (Special trip marked as 1, Casual visit marked as 0).	Uncertainty
Visitor's gender for his/her visit in City i	S_i	Visitor's gender for his/her visit in City i. Female marked as 1, male marked as 0.	Uncertainty
Visitor's age for his/her visit in City i	A_i	Visitor's age for his/her visit in City i. (Unit: year; Age data range: 18-65).	+
Visitor's educational background for his/her visit in City i	E_i	Visitor's educational background for his/her visit in City i (Unit: year). Data range: 12-18 years.	+
Visitor's personal monthly income for his/her visit in City i	MI_i	Visitor's personal monthly income for his/her visit in City i (Unit: NTD).	+

Basic data analysis of interviewed visitor

Analysis of socio-economic index

From descriptive statistical analysis, it is clear to show that the majority of visitors interviewed were males: males were total 77 people, namely 59.70 percent of total interviewees; however, the females were 52 people, namely 40.30 percent of total interviewees. In addition, the visitors' ages between 35 to 44 years were the most which occupied 25.60 percent of total interviewees. For the ages between 25 to 34 years were the second with total 32 people. Overall, the samples of interviewees' ages were distributed evenly, this shows the attractions of Liuqiu scenic area do not focus on specific age group. Moreover, student was the major interviewee with total 35 people, which was 27.20 percent of total interviewees. The second most population was service industry, which was 18.60 percent of total interviewees. However, the lowest proportion of interviewees was agricultural worker, which was only 3.10 percent of total interviewees.

In terms of interviewees' education background, undergraduates were the highest majority, which took 36.40 percent of total interviewees. This situation of education

background might relate to the generalization of universities nowadays. With regards to the personal income, the interviewees' personal monthly incomes between NT$28,001 to NT$38,000 took the highest proportion with total 39 people, which was 30.20 percent of total interviewees. However the personal monthly incomes from NT$28,001 to NT$ 38,000 was the second, which was 24.80 percent of total interviewees. It can be inferred the reason might be the low ticket price in scenic area. Based on the analyses, it can be seen the wide range of visitors attracted by scenic area.

The analysis of tourism attitude and behavior for Liuqiu scenic area

In respect of the importance of leisure activities, 27.10% percent of interviewees expressed their emphasis on leisure activities, and 33.30 percent of interviewees put high value on it. Therefore, about total 60.40 percent of interviewees attached importance to leisure activities. According to this research, it reflected that it is a common phenomenon for people nowadays to pay attention on personal leisure activities. Furthermore, in recent year, the times of visiting scenic area with "once" was the most for the interviewees, and that was total 86 people with 66.70 percent of total interviewees. Then, the times of visiting scenic area with "twice" was the next occupied 17.10 percent of total interviewees. It is clear to find that the more times visitors visit, the lower proportion it has. This might relate to the distance between interviewees' accommodation location and scenic area. If visitors' accommodation locate is far from scenic area, the trip arrangement should include more factor concerns such as transportation fee, accommodation cost and days of tourism. Therefore, the times of visiting scenic area will relatively lower than the visitors who live near the scenic area.

In addition, by analyzing the interviewee' behaviors, 20.20 percent of interviewees indicated that they understood the plan of scenic area. It relates to the interviewees who value the leisure activities. Compared to the normal people, those people will take more notice of related tourism information or the plan of tourist sites. Besides, 75.20 percent of interviewees indicated to support this plan, also 77.50 percent of interviewees expressed that they will increase the times of visiting after the scenic area plan is completed. In general, visitors show positive reactions on scenic area plan. Accordingly, their attitude will benefit the promotion of scenic area plan.

The analysis of WTP in scenic area

Among the 129 interviewees, the average transportation fee is NT$1631.01. If one-way ticket price from Taiwan's Tze Chiang train was calculated as relative-price basis, most of interviewees were middle and long-range visitors. Their average total cost was NT$843.46. Except for transportation fee, "Total cost" meant the expenses of food, accommodation, ticket

and souvenir. As for "Travel cost", it was the sum of visitors' transportation fee and the total expense. Thus, the average travel cost was NT$1,454.42. After the scenic area is completed, interviewees' average WTP were NT$8,558.14.

By reviewing data, NT$9,000 was the most WTP for total 40 people, which was 31.10 percent of total interviewees. The next visitors' WTP was NT$7,500, which was 18.60 percent of total interviewees. Based on the survey results, it showed that visitors' WTP was from NT$4,500 to NT$12,000, which was 88.50 percent of total interviewees.

The difference comparison of interviewed visitor's evaluation model

From the data shown in Table 3, the proportion of correct predictions in Logit model (82.06%) is higher than the one in Probit model (81.69%). Based on the analysis result of Probit and Logit models, both of them are close at Log-likelihood Value. However, Logit model is slightly higher than Probit model on its correct predictive validity; hence, the evaluation result is similar to the research.

Table 3. Regression model results of interviewed visitor's WTP

Explanatory variable		Probit model	Logit model
Item	Symbol		
Constant term	α, β	-0.7635 (-0.578)	-1.2980 (-0.691)
Visitor's visit times in City i	V_i	0.1786** (1.798)	0.3117* (2.187)
Whether they know	$KNOW_i$	0.3343 (0.997)	0.5657 (1.067)
Recreation importance	$RIMP_i$	-0.2508 (-1.325)	-0.3425 (-1.318)
Visitor's travel cost for his/her visit in City i	TC_i	0.1297E-03* (1.509)	0.2113E-03 (1.431)
Whether to increase travel times	INC_i	0.8148** (3.220)	2.1908** (2.432)
Casual visit or special trip	$TYPE_i$	0.4128* (1.501)	0.6976* (1.462)

Explanatory variable		Probit model	Logit model
Item	Symbol		
Visitor's gender for his/her visit in City i	S_i	0.2076 (0.758)	0.3567 (0.845)
Visitor's age for his/her visit in City i	A_i	0.3978E-01 (0.379)	0.7984E-01 (0.459)
Visitor's educational background for his/her visit in City i	E_i	-0.4908E-01 (-0.708)	-0.8023E-01 (-0.657)
Visitor's personal monthly income for his/her visit in City i	MI_i	0.7452E-05 (1.097)	0.2237E-04 (1.123)
Log-likelihood value		-82.5838	-82.4982
Restricted log-likelihood		-91.9318	-91.9318
Chi-squared		33.2874	33.7662
Proportion of correct predictions		0.8169	0.8206
N		129	129

Annotation: ( ) is t value; *** indicates t-tests pass the significant level of 0.01, ** the level of 0.05, and * the level of 0.10; $\chi^2 (0.01,10) = 45.75$; Symbol α, β indicates the constant term of Probit and Logit models, respectively

The measurement of interviewee's WTP

The analyses were organized in Table 4. Regarding the interviewees' revisit after scenic area is complete, the result shows their WTP in the Probit model is NT$9,107; whereas NT$9,888 in the Logit model.

Table 4. Average WTP of interviewed visitor's

Evaluation method / Evaluation item	Probit model	Logit model
WTP (NT$)	9,107	9,888

The model construction of utility evaluation for visitor's usage in Liuqiu scenic area

The research took OLS and Probit models for empirical analysis. Table 5 illustrated the influences from the selected variables on WTP in scenic area.

Table 5. Explanation of variable definition and expected symbol inside the empirical model

Variable	Symbol	Variable definition	Expected symbol
Inhabitant's WTP on environment maintenance	WTW_i	Interviewed inhabitant's WTP on environment maintenance Unit: NT dollar.	+
The frequency of scenic-area usage within one moth	V_i	Interviewed inhabitant's frequency of scenic-area usage within one month. Unit: time.	+
Personal impression on scenic-area environment	IM_i	Interviewed inhabitant's impression on scenic area and environment nearby. 1 : very dirty 2 : dirty 3 : fine 4 : clean and tidy 5 : very clean and tidy 6 : do not have any impression	Uncertainty
Personal viewpoints of environment maintenance	$VIEW_i$	After building scenic area, interviewed inhabitant's viewpoints on environment maintenance. 1 : The highest importance 2 : High importance 3 : Normal importance 4 : Less importance 5 : The lowest importance	+
Inhabitant's age	A_i	Interviewed inhabitant's age. Unit: years. Age range: 18-65. NT dollar.	Uncertainty
Personal monthly income	MI_i	Interviewed inhabitant's personal monthly income. Unit: NT dollar.	Uncertainty

The data analysis of interviewed inhabitant's descriptive statistics
Analysis of interviewed inhabitant's socio-economic index

In the aspect of socio-economic index, the interviewed inhabitants' genders showed no significant differences. Among the genders, total 45 males were slightly more than females, namely 51.70 percent of total interviewees. However, total 42 females, which was 48.30 percent of total interviewees. On the part of interviewed inhabitants' age, the range from 55 to 64 years old was the most. There were a total of 44 people, which was 50.60 percent of total interviewees. Also, the second most was the ages from 45 to 54 years old with a total of 29 people. According to the interviewed inhabitants' occupation, there were total of 46 people who were businessman were the most, which was 52.90 percent of total interviewees. The second was self-employed, which was 23 percent of total interviewees. The fewest proportion of occupation for the interviewed inhabitant was agriculturists, which only was 1.20 percent of total interviewees. The establishment of scenic area might attract more visitors. Meanwhile, most old urban areas and its surroundings not only are famous for business clusters, but also have frequent commercial activities. Therefore, this observation confirms the validity of the result, namely it is reasonable that most interviewed inhabitants engage in business.

In the aspect of educational background, the most interviewed inhabitants were below the senior high school, occupying 62.10 percent of total interviewees. The reason might attribute to the interviewed inhabitants' elder age. In the aspect of personal income, the personal monthly incomes of most interviewed inhabitants interviewees' was from NT$28,001 to NT$38,000. There were 35 people, which took the highest proportion of 40.20 percent in total interviewees. In addition, the second most incomes was from NT$38,001 to NT$48,000, which occupied 27.60 percent of total interviewees. Furthermore, the interviewed inhabitants' monthly incomes under NT$28,000 was 17.30 percent. Because most interviewed inhabitants engage in business, it could be inferred that the survey time just coincides with low-season for tourism.

The cognitive analysis of scenic-area user's behavior and plan

According to the analysis of scenic-area users' behavior from interviewed inhabitants, this research found there were about 50 percent of people ever using scenic area. Among the utility rate, the 26.40 percent of total interviewees frequently use scenic area was more than 1 to 5 times a month on average. This indicates scenic area could further function as neighborhood/community parks for people who have high usage frequency. Meanwhile, by investigating the usage rate from 50 percent of interviewed inhabitants, it conforms to the original planning goals to upgrade inhabitants' living quality as well as to maintain the rights of inhabitants near the scenic area. However, there was still 50 percent of people never

visiting scenic area. This phenomenon is really worth to discuss whether it relates to the inhabitants' personal life style. By further analysis on the 50 percent of usage rate, inhabitants' main purpose was to go for a walk, which took 42.60 percent of total interviewees. The second purpose is exercise, which occupied 35.60 percent of total interviewees. The third purpose is family activity, which had 13.80 percent of total interviewees. Base on the analysis results, scenic area is an essential public facility for local inhabitants' daily life.

With regard to interviewed inhabitants' cognition to the scenic-area plan, almost 90.80 percent of inhabitants all agreed to implement the scenic-area plan. It shows that inhabitants approve of the scenic-area establishment. As for the environment inside and nearby scenic area, 55.20 percent of interviewed inhabitants expressed acceptable. However, 4.80 percent of inhabitants thought the environment was dirty in scenic area, including the comment "dirty" with 1.20 percent and "very dirty" with 3.40 percent. On the other hand, 92 percent of interviewed inhabitants expressed that the government should supplement the scenic-area environment, including the comment "supplements must be the priority, regardless of governmental funds condition" with 62.10 percent and "supplements must be the priority, if the governmental funds is sufficient" with 29.90 percent. Moreover, in the role of environment maintenance, 58.70 percent of interviewed inhabitants thought the main role should be the PingTung County Government while the inhabitants should participate as the auxiliary. 17.20 percent of interviewees thought the government must have full responsibility for environment maintenance. Only 11.50 percent of interviewees thought inhabitants should act as the main role while the government acts as auxiliary. Overall, most of interviewed inhabitants approve of environment maintenance regardless of role assignment.

The analysis of interviewed inhabitant's WTP for scenic area

This research used hypothetical situation for scenic-area environment maintenance instead of revisit in scenic area, in order to measure interviewed inhabitants' WTP for scenic area. If currency was used for the scenic-area environment maintenance, the average was NT$ 232 with the maximum NT$ 5,000 and minimum NT$ 0. According to Table 4-14, the non-WTP inhabitants occupy 54 percent of total interviewees. Whereas, the inhabitants' WTP had 28.70 percent of total interviewees, the payment of WTP from NT$500 to NT$1000 was the most. Based on the analysis result, if WTW was used for scenic-area environment maintenance, the non-WTW people occupied 55.80 percent of total interviewees. However, the most WTW of people was one hour per year, which took 20.90 percent of total interviewees. Moreover, the second was the people's WTW with two, four and eight hours per year, which had 10.50 percent and 4.60 percent respectively of total interviewees. When the research further investigated the viewpoint of inhabitants' non-WTP, the proportion of

WTP with "Zero" was higher than WTW with "Zero." This statistic result showed that it would be better to use WTW for the measurement on scenic-area environment maintenance. Therefore, this research used inhabitants' WTW to represent their WTP. Later, the detail of comparison between WTP and WTW will be described in the following content.

The difference comparison of interviewed inhabitant's evaluation model

In general, OLS and Probit models showed no significant difference on evaluation by their own variables. Regarding the overall explanation of model, the criterion in OLS and Probit models were different, therefore the research cannot compare their overall explanation.

Table 6. Regression model results of interviewed inhabitant's WTW

Explanatory variable		Probit model	OLS model
Item	Symbol		
Constant term	α, β	-102.4396 (-0.361)	-1.9012*** (-2.576)
Willingness to pay	WTP_i	2.6292*** (5.182)	0.1192E-02* (1.826)
The frequency of scenic-area usage	V_i	31.4821** (2.307)	0.4620E-01** (1.592)
Personal impression on scenic-area	IM_i	-49.7129 (-0.419)	-0.1372 (-0.541)
Personal viewpoints	$VIEW_i$	52.2384 (0.612)	0.2175 (0.876)
Inhabitant's age	A_i	-19.5201 (-0.226)	-0.2934E-01 (-0.142)
Visitor's personal monthly income	MI_i	0.1209E-01*** (2.130)	0.3015E-04*** (3.295)
R^2		0.4025	--
Adj R^2		0.3821	--
Chi-squared		--	26.2901
Log-likelihood value		--	-40.9014
Restricted log-likelihood		--	-51.6382

Proportion of correct predictions	--	65.3027%
N	87	87

Annotation: ( ) is t value; *** indicates t-tests pass the significant level of 0.01, ** the level of 0.05, and * the level of 0.10; χ^2 (0.01, 6) =26.2901; Symbol α, β indicates the constant term of Probit and OLS models, respectively

The measurement of interviewed inhabitant's WTW

The currency value of interviewed inhabitants' average WTW can be seen in Table 7. The result shows that currency value of their WTP in the OLS model is NT$845; whereas NT$930 in the Logit model.

Table 7. Average WTW of interviewed inhabitant's

Evaluation method / Evaluation item	OLS model	Probit model
WTW (NT$)	NT$845	NT$930

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CONCLUSION AND SUGGESTION

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Research conclusion

(1) Based on the analysis of socio-economic index, males are the most interviewed visitors, which is 59.70 percent of total interviewees. Meanwhile, the interviewed visitors' age from 35 to 44 years old is the most, which takes 25.60 percent of total interviewees. In general, the samples from each interviewed visitors' ages are distributed evenly. This analysis shows the attractions of Liuqiu scenic area do not focus on specific age group. Moreover, student is the majority in the interviewed visitors' occupation, which occupies 27.20 percent of total interviewees. In the aspect of interviewees' education background, undergraduates are the highest majority, which take 36.40 percent of total interviewees. This might relate to the generalization of universities nowadays. For the personal income, the interviewees' personal monthly incomes from NT$28,001 to NT$38,000 takes the highest proportion. There are total 39 people, which is 30.20 percent of total interviewees. Based on the analysis, It can be inferred the reason might attribute to the low ticket price in scenic area. Therefore, the wide range of visitors can be attracted by scenic area.

(2) To analysis visitors' WTP, the proportion of correct predictions in Probit and Logit models are 81.69 percent and 82.06 percent respectively. When the WTP and WTW methods are used to estimate the WTP of visitors and inhabitants, they are all equipped with certain explanations regardless of any function types. As a result, this shows the construction of evaluation models in this research is principally feasible.

(3) In order to measure interviewees' WTP, it can be estimated via viewpoints of visitors and inhabitants. Based on the evaluation results for visitors, their WTP in the Probit and Logit models are NT\$9,107 and NT\$9,888 respectively. As for the inhabitants' WTW in the OLS and Probit models are NT\$845 and NT\$930 respectively. Compared to the visitors' WTP, the research found that inhabitants' WTW has smaller difference between evaluation result and average number. As a result, OLS model is adopted as a basis in the evaluation model of the integrated information.

(4) In the previous researches, WTP is usually represented by currency. However, this research attempted at using WTW as an alternative CVM option to measure the WTP. Furthermore, WTW can accordingly represent inhabitants' WTP. During the difference comparison between inhabitants' WTP and WTW, this study found that the distribution trend of WTW shows more even from its sampling distribution. It shows inhabitants show the consistency on the WTW.

Suggestions for follow-up researches

(1) Regarding the goodness of fit for the mode, this research did not conduct further verification. In order to effectively reflect the economic benefits of scenic area, the future researches might adjust related parameters, endue variables with weight and acquire more accurate results by cross comparison and verification.

(2) When WTW converts into currency unit, it is decided by "Wage rate." Furthermore, "Wage rate" is decided by the sampling in this research. For this reason, the issue "Whether this calculation causes any deviation in the evaluation mode?" still awaits in-depth investigation in future researches. On the other hand, the requirement and necessary methods of the wage-rate conversion should be further clarified as well. For acquiring more rational values, the future researchers are advised to conduct regression analysis on wage rate and personal socio-economic variable.

(3) The issue "Different seasons (i.e. low season and peak season) of tourism activities in scenic area" is not considered in the research. Hence, it can be recommended that the related researchers could consider this viewpoint in the future so as to reduce the deviation from the results.

(4) The economic benefits measured in this research only focuses on scenic-area users. However, it is a wide range that economic benefits are included. To obtain more

complete investigation on economic evaluation, other classified values could also be investigated in further studies.

REFERENCES

1. Awad, I., and Hollander, R. (2010), "Applying contingent valuation method to measure the total economic value of domestic water services: A case study in Ramallah governorate, Palestine", *European Journal of Economics, Finance and Administrative Sciences*, Issue 20, pp. 76 – 93.

2. Barnard, E., and Mitra, A. (2010), "A contingent valuation method to measure willingness to pay for eco-label products", *Proceedings of the Academy for Economics and Economic Education*, Vol. 13 No. 2, pp. 5 – 10.

3. Barrio, M., and Loureiro, M.L. (2010), "A meta-analysis of contingent valuation forest studies", *Ecological Economics*, Vol. 69 No. 5, pp. 1023 – 1030.

4. Carson, R.T. (2012), "Contingent valuation: A practical alternative when prices aren't available", *The Journal of Economic Perspectives*, Vol. 26 No.4, pp. 27 – 42.

5. Chen, B., He, G., Yang, J., Zhang, J., Su, M., and Qi, J. (2012), "Evaluating ecological and economic benefits of a low-carbon industrial park based on millennium ecosystem assessment framework", *The Scientific World Journal*, Article ID 909317.

6. Choi, A.S., Ritchie, B.W., Papandrea, F., and Bennett, J. (2010), "Economic valuation of cultural heritage sites: A choice modeling approach", *Tourism Management*, Vol. 31 No. 2, pp. 213 – 220.

7. Fan, N., and Long, Y. (2012), "Evaluation for economic benefits of urban land use in China", *Computational and Information Sciences (ICCIS)*, *Fourth International Conference in Chongqing, China*, 2012, Conference Publishing Services, pp. 1123 – 1126.

8. Guto, S.N., Pypers, P., Vanlauwe, B., De Ridder, N., and Giller, K.E. (2011), "Tillage and vegetative barrier effects on soil conservation and short-term economic benefits in the central Kenya highlands", *Field Crops Research*, Vol. 122 No. 2, pp. 85 – 94.

9. Hof, B., Heyma, A., and Der Hoorn, T.V. (2012), "Comparing the performance of models for wider economic benefits of transport infrastructure: Results of a Dutch case study", *Transportation*, Vol. 39 No. 6, pp. 1241 – 1258.

10. Howley, P., Hynes, S., and O'Donoghue, C. (2010), "The citizen versus consumer distinction: An exploration of individuals' preferences in contingent valuation studies", *Ecological Economics*, Vol. 69 No. 7, pp. 1524 – 1531.

11. Lee, S.J., Chung, H.K., and Jung, E.J. (2010), "Assessing the warm glow effect in contingent valuations for public libraries", *Journal of Librarianship and Information Science*, Vol. 42 No. 4, pp. 236 – 244.

12. Madureira, L., Nunes, L.C., Borges, J.G., and Falcao, A.O. (2011), "Assessing forest management strategies using a contingent valuation approach and advanced visualisation techniques: A Portuguese case study", *Journal of Forest Economics*, Vol. 17 No. 4, pp. 399 – 414.

13. Magnus, A., Cadilac, D., Sheppard, L., Cumming, T., Pearce, D., and Carter, R. (2010), "Economic benefits of achieving realistic smoking cessation targets in Australia", *American Journal of Public Health*, Vol. 101 No. 2, pp. 321 – 327.

14. Martinez-Espirieira, R., and Lyssenko, N. (2012), "Alternative approaches to dealing with respondent uncertainty in contingent valuation: A comparative analysis", *Journal of Environmental Management*, Vol. 93 No. 1, pp. 130 – 139.

15. Ren, H., and Gao, W. (2010), "Economic and environmental evaluation of micro chp systems with different operating modes for residential buildings in Japan", *Energy and Buildings*, Vol. 42 No. 6, pp. 853 – 861.

16. Ryan, A.M., and Spash, C.L. (2011), "Is WTP an attitudinal measure? empirical analysis of the psychological explanation for contingent values", *Journal of Economic Psychology*, Vol. 32 No. 5, pp. 674 – 687.

17. Simpson, S.N., and Hanna, B.G. (2010), "Willingness to pay for a clear night sky: Use of the contingent valuation method", *Applied Economics Letters*, Vol. 17 No. 11, pp. 1095 – 1103.

18. Veronesi, M., Alberini, A., and Cooper, J.C. (2011), "Implications of bid design and willingness-to-pay distribution for starting point bias in double-bounded dichotomous choice contingent valuation surveys", *Environmental and Resource Economics*, Vol. 49 No. 2, pp. 199 – 215.

19. Ye, C.Q., Li, C., and Mou, L. (2013), "The comprehensive economic benefits evaluation of power generation projects under the background of low-carbon economy", *Advanced Materials Research*, Vol. 662, pp. 999 – 1004.

20. Zhao, P., and Fang, J. (2012), "Research and evaluation on procurement techno-economic benefits of NC grinder technology projects based on the AHP", *National Conference on Information Technology and Computer Science*, *Proceedings of National Conference in Lanzhou, China*, 2012, Atlantis Press, pp. 985 – 988.

A CROSS-AREACOMPARISON OF INVESTIGATION ON THE PERSONAL VALUE FACTORS THAT INFLUENCE CONSUMERS' LUXURY FASHION BRAND CHOICE BASED ON BRAND CHARACTERISTICS IN TAIWAN AND HONG KONG

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ABSTRACT

As for luxury goods, the strong purchasing power of Asianshas instigated manyglobal luxury brands to set up flagship stores in major cities in Asia.The luxury goods market in Asiaexpanded continually, however most of previous studies in luxury brand choice were conducted in Western countries. Due to different culture, there is a need for research in luxury brand choice in Asian countries.The study explores the personal value factors that affect Taiwan and Hong Kong consumer's brand choice in luxury fashion goods based on the characteristics that the brand owns, andmakes cross-areacomparisons between thesetwo markets.By comparing thedifferences and similaritiesin personal value factorson brand characteristicsbetween two markets, luxury brandfirmsin Taiwan and Hong Kongcan formulate different marketing strategiesto promote their luxury products.

Keywords: luxury, purchasing decision,value factor, brandcharacteristic, cross-area comparison, Taiwan, Hong Kong

INTRODUCTION

In recent years, the rapid economic growth in Asia accompanied by increased levels of household income drives strong demand for luxury goods in Asia. Within a decade, Asia will create 50-60% of luxury revenue, forecasted by Economist Intelligence Unit (Economist Intelligence Unit, 2013). However most of previous studies in luxury brand choice were conducted in Western countries. Due to different culture, there is a need for research in luxury brand choice in Asian countries.

Among Asian countries, both Taiwan and Hong Kong are two of the world's leading luxury markets. Ladies in Taiwan and Hong Kong like to have a luxury package at least. They dress with a boutique bag in order to show their own fashion sense and discuss each other's boutique bag when they are dating together. There are variety luxury brands. How consumers choose a luxury brand becomes an important issue. Some previous studies indicated that personal values influence consumer's brand choice (Vinson, 1977; Woodside, 1983). The levels of importance of different personal values vary for different people who have different cultures. Thus the personal values affecting brand choice for consumers in Taiwan may vary with consumers in Hong Kong. The aim of this study is to compare consumer luxury brand choice behaviour between Taiwan and Hong Kong in terms of personal values. In this study, the luxury brand consists of three characteristics, they are: placement of advertising, iconic brand elements, and heritage. This study tests the effects of attributes of personal values on these three brand characteristics. This study also tries to find out any gaps in the personal values between Hong Kong people and Taiwan people in consuming luxury products. The results of this study provide guidance for luxury brand marketers in Taiwan and Hong Kong to develop their marketing strategies in order to promote their luxury products according to three different brand characteristics.

LITERATURE REVIEW

Luxury

In 1990s, people regarded luxury as a core driver of consumer preferences and usage (Dubois and 1993 Duquesne). Nueno and Quelch (1998) later considered the concept of luxury brands as: premium-priced products, a status symbol, an investment, having consistent delivery of premium quality across all products, owning a heritage of craftsmanship, having a recognisable style or design, having a limited production run to ensure exclusivity, owning a market position that combines emotional appeal with product excellence, having a global reputation, associated with the country of origin that has strong reputation as a source of excellence in the relevant product category, having an element of uniqueness in each product, having the ability to time design shifts when the category is fashion-intensive, communicating the personality and values of its

creator. Wong and Zaichkowsky (1999) mentioned that luxury brands must not only be good quality, but must also be able to fulfil customers' emotional needs.

In 2000s, researchers provided different definitions of luxury. Phau and Prendergast (2000) considered that the term "luxury" is a subjective concept, and the perception of whether it is or not a luxury brand is turn on the context and the person concerned. Phau and Prendergast (2000) demonstrated that brands pursue to their ability to evoke exclusivity, brand identity, brand awareness and perceived quality for the consumer. Vigneron and Johnson (2004) argued that luxury product brings the owners of product, self-esteem, to meet their psychological and functional requirements. Wiedmann, Hennings, and Siebel (2007) stated that luxury goods are non-essential items or services, these objects contribute to luxurious living by providing an indulgence or convenience beyond the indispensable minimum. Tynan, McKechnie, and Chuon (2010) explained that the term "luxury brands" identifies high quality, expensive and non-essential products and services that are perceived by consumers as rare, exclusive, prestigious, and authentic and that offer high levels of symbolic and emotional value.

Recently, Godey, Pederzoli et al. (2011) pointed out that this harmonises the general consensus in literature that what consumers' desire from a luxury brand are: beauty, rarity, quality, price and an inspirational brand that endorses the product. Li, Li and Kambele (2012) simply described that luxuries are objects of desire that provide pleasure.

Brand characteristics

Thakor and Lavack (2003) pointed out that consumer perceptions of brands are likely to be shaped by brand characteristics such as intrinsic properties carried or owned by the brand name. Although different researchers provided different definitions of luxury, however, all luxury products show some common characteristics. For example, many researchers have mentioned other brand characteristics for a successful luxury brand, which involve recognisable and iconic style, design, products or symbols (Nueno and Quelch 1998), heritage (Beverland 2004; Moore and Birtwistle 2005) advertising and endorsements (Kent, Macdonald et al. 2000; Beverland 2004; Moore and Birtwistle 2005; Okonkwo 2007),and country of origin (Thakor and Lavack 2003), in all these and other relevant characteristics constitute the complete identity of the brand. Therefore, these three characteristics were chosen in this study, given the amount of importance as predictors and commonality they have in each brand, although the plethora of characteristics that a brand owns.

Doyle (1990) also mentioned that advertising helps in creating identity and awareness. Moore, Fernie et al. (2000) noted that advertising can support and establish brand image. Lee (2002) indicated that a brand that is highly accessible in memory has a greater chance of being

considered and selected than a brand that is less accessible in memory. Therefore, advertisement is a crucial characteristic for a brand to own.

Van Rij (1996) advocated that a configuration of brand symbols and content conveys a brand image, in which consumers uses the differences between brand images to make their choices amongst similar products. Fionda and Moore (2009) stated that iconic elements or products of a brand are important as they epitomise the brand signature. Therefore, iconic elements as symbolic characteristics were one of the strongest predictors of conspicuous consumption of specific brands (O'Cass and Frost's, 2002).

Heritage brand is considered as a brand which uses its history as part of its key brand identity found in its track record, longevity, core values, use of symbols and particularly in an organisational belief that its history is important (Urde, 2007). Therefore brand heritage would influence consumer choice (Menkes 2010) as well as consumer's attachment to the brand (Merchant and Rose 2012).

This study measures consumer brand choice based on three brand characteristics: advertisement, iconic brand elements, and heritage brand.

Personal values

Personal values are crucial elements in consumers' cognitive structure (Homer and Kahle 1988) that relate to product and brand choice criteria (Vinson, 1977; Woodside, 1983). Personal values are closely linked to needs (Lai 1995, p.382) and guide principles in people's lives (Schwartz and Sagiv 1995). Each person holds different values with various degrees of importance (Bardi and Schwartz, 2003). Therefore, it may be possible to better understand consumer behavior by understanding consumers' personal values, (Homer and Kahle 1988). Schwartz and Bilsky (1987) classified personal values into five commonalities, which: (1) are concepts or beliefs; (2) encompass desirable end states or behaviour; (3) are enduring; (4) affect attitudes and behaviours, and (5) have a hierarchical structure with respect to their relative importance. Recently, Linderman and Verkasalo (2005) refined Schwartz's 57 measurement questions 10 questions. They are: Power, Achievement, Hedonism, Stimulation, Self-direction, Universalism, Benevolence, Tradition, Conformity, andSecurity, This study adapts Schwartz and Bilsky's (1987) measurements for personal values.

RESEARCH METHODOLOGY

Research model

The aim of this study is to explore Hong Kong and Taiwan consumers' brand choice behaviors based on personal value factors, which guide them to choose a brand. Figure 1 shows the research model of this study.

PESONALVALUES
(Hong Kong and Taiwan)
- Power
- Achievement
- Hedonism
- Stimulation
- Self-direction
- Universalism
- Benevolence
- Tradition
- Conformity
- Security

CONSUMER BRAND CHOICE BASED ON:
- Advertisement placement
- Iconic Elements
- Heritage Brand
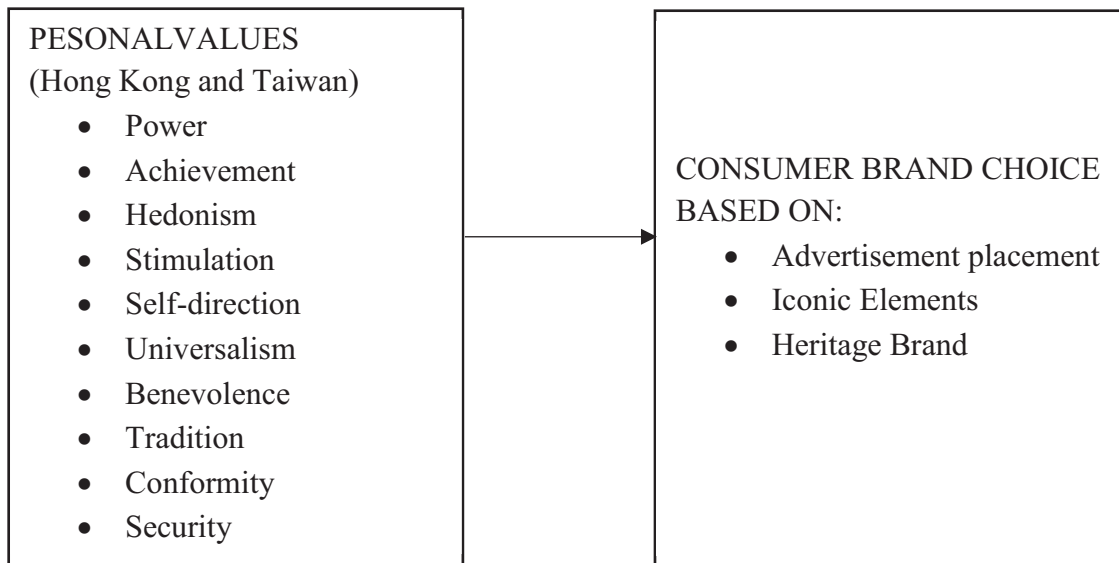
Figure 1

Samples and data collection

In Hong Kong, atotal of 312 people participated in the survey that was administered by a marketing research company. The usable sample size is 301, for which148 surveys (49.2%) were collected in Causeway Bay and 153 surveys (50.8%) were collected in Tsimshatsui.

In Taiwan, the method of collect datawas that filteringout from friends in the appropriate list of key persons, and these who are listedhave specialway to find the objectsconsumers who have purchasedluxury goods. The questionnairesare emailed to them andask them to help find suitable objects respondents. The reason why we use this collection method is Taiwanese culturethat high income consumers, especially lady, will be afraid that the questionnaires professionalsclose to her, and theyalwaysrefused to help answer the question. Finally, there are 190 useful simples.

In this study, the brands that were mentioned by respondents were collected and then categorized according to the following three characteristics: (1) if they had advertisement places in major

Hong Kong or Taiwan fashion magazines or not; (2) ifthey had iconic brand elements (excluding their name and logo), and (3) if they were a heritage brand or not.

RESULTS AND DISSCUSSIONS

Advertising character

Table 2 shows the mean and standard deviation of different dimensions of personal values rated by consumers in Hong Kong and Taiwan. The values of importance for all the dimensions of personal values placed by consumers in Taiwan are higher than the values rated by consumers in Hong Kong. However, there is no single directional difference in the values of importance for the dimensions of personal values rated by two groups of consumers in Hong Kong.

Table 2: Mean and standard deviation of advertising and no advertising groups

	Advertising placements				Non Advertising placements			
	Mean		S.D.		Mean		S.D.	
	HK (n=252)	TW (n=144)	HK	TW	HK (n=49)	TW (n=41)	HK	TW
Power	3.12	3.40	0.869	0.963	3.12	3.12	0.857	1.077
Achievement	3.52	3.90	0.830	0.875	3.43	3.51	0.979	1.227
Hedonism	3.52	3.91	0.811	0.810	3.63	3.78	0.727	0.936
Stimulation	3.31	3.78	0.888	0.848	3.45	3.66	0.792	0.911
Self-direction	3.59	4.01	0.760	0.762	3.73	3.93	0.700	0.755
Universalism	3.58	3.97	0.777	0.752	3.47	3.95	0.710	0.921
Benevolence	3.60	3.95	0.732	0.732	3.59	3.80	0.788	0.813
Tradition	3.59	3.83	0.760	0.793	3.49	3.54	0.794	0.925
Conformity	3.69	3.74	0.726	0.819	3.47	3.73	0.793	0.775
Security	3.80	4.22	0.716	0.711	3.73	4.22	0.758	0.725

Table 3 shows the results of Wilks' lambda statistic. The results of analysis (at 95 percent confidence limit) indicate that there is no significant difference across the different buying groups in Hong Kong. However, the results of analysis indicate that achievement (F value = 5.066) and tradition (F value = 4.141) are the most important dimensions of personal values that cause consumers to purchase advertised luxury products in Taiwan.

Table 3: Tests of equality of group means (advertising vs no advertising)

	HK				TW			
	Coefficients	Wilks' Lambda	F	Sig.	Coefficients	Wilks' Lambda	F	Sig.
Power	-0.153	1.000	0.003	0.957	0.248	0.986	2.573	0.110
Achievement	0.406	0.998	0.508	0.476	0.658	0.973	5.066	0.026*
Hedonism	-0.205	0.997	0.820	0.366	-0.619	0.996	0.757	0.385
Stimulation	-0.096	0.997	1.046	0.307	-0.066	0.997	0.610	0.436
Self-direction	-0.698	0.995	1.580	0.201	-0.081	0.998	0.354	0.552
Universalism	0.425	0.997	0.784	0.377	-0.189	1.000	0.010	0.920
Benevolence	-0.082	1.000	0.010	0.922	0.272	0.993	1.216	0.272
Tradition	0.081	0.998	0.665	0.415	0.778	0.978	4.141	0.043*
Conformity	0.825	0.988	3.56.	0.060	-0.335	1.000	0.001	0.976
Security	-0.238	0.999	0.311	0.578	-0.422	1.000	0.001	0.973

Iconic character

Table 4 compares the mean and standard deviation of prefer iconic elements and no iconic elements groups. The values of importance for most dimensions of personal values rated by consumers in Taiwan who purchased luxury products with iconic elements are higher than the values rated by consumers in Taiwan who purchased luxury products with no iconic elements. However, it shows an opposite trends where the values of importance for most dimensions of personal values rated by consumers in Hong Kong who purchased luxury products with iconic elements are lower than the values rated by consumers in Hong Kong who purchased luxury products with no iconic elements.

Table 4: Mean and standard deviation of iconic element sand no iconic elements groups

	Iconic Elements				No Iconic Elements			
	Mean		S.D.		Mean		S.D.	
	HK (n=223)	TW (n=139)	HK	TW	HK (n=78)	TW (n=46)	HK	TW
Power	3.11	3.42	0.828	0.977	3.13	3.11	0.972	1.016
Achievement	3.41	3.91	0.826	0.908	3.41	3.52	0.932	1.110
Hedonism	3.48	3.92	0.793	0.835	3.72	3.76	0.788	0.848
Stimulation	3.33	3.77	0.898	0.871	3.35	3.70	0.803	0.840
Self-direction	3.58	3.99	0.766	0.757	3.71	3.98	0.705	0.774
Universalism	3.56	3.99	0.768	0.742	3.55	3.89	0.767	0.924
Benevolence	3.58	3.97	0.748	0.722	3.65	3.76	0.718	0.822

	Iconic Elements				No Iconic Elements			
	Mean		S.D.		Mean		S.D.	
	HK (n=223)	TW (n=139)	HK	TW	HK (n=78)	TW (n=46)	HK	TW
Tradition	3.60	3.83	0.752	0.825	3.42	3.59	0.802	0.832
Conformity	3.64	3.78	0.739	0.778	3.60	3.59	0.747	0.884
Security	3.78	4.24	0.734	0.690	3.82	4.13	0.722	0.778

In Table 5, the results of Wilks' lambda statistic indicate that hedonism (F value = 5.427) is the most important dimension of person values that causes consumers in Hong Kong to buy luxury products with iconic elements and achievement (F value = 5.531) is the most important dimension of personal values that causes consumers in Taiwan to purchase luxury products with iconic elements.

Table 5: Tests of equality of group means (iconic elements vs no iconic elements)

	HK				TW			
	Coefficients	Wilks' Lambda	F	Sig.	Coefficients	Wilks' Lambda	F	Sig.
Power	0.277	0.995	0.020	0.888	0.280	0.982	3.378	0.068
Achievement	-0.532	0.982	1.387	0.240	0.622	0.971	5.531	0.020*
Hedonism	0.817	1.000	5.427	0.020*	0.106	0.993	1.260	0.263
Stimulation	-0.477	0.995	0.027	0.870	-0.269	0.999	0.255	0.614
Self-direction	0.363	1.000	1.644	0.201	-0.496	1.000	0.013	0.911
Universalism	-0.433	0.998	0.008	0.927	-0.128	0.997	0.492	0.484
Benevolence	0.397	0.986	0.530	0.467	0.581	0.985	2.737	0.100
Tradition	-0.439	0.999	1.277	0.259	0.276	0.984	2.924	0.089
Conformity	0.134	1.000	0.154	0.695	0.170	0.989	2.073	0.152
Security	-0.067	0.995	0.083	0.773	-0.146	0.995	0.887	0.347

Heritage character

Table 6 compares the mean and standard deviation of prefer heritage brand and non-heritage brand groups. The values of importance for most dimensions of personal values rated by consumers in Taiwan who purchased heritage brand luxury products are higher than the values rated by consumers in Taiwan who purchased luxury products with no iconic elements. The values of importance for some dimensions of personal values rated by consumers in Hong Kong who purchased heritage brand luxury products are higher than the values rated by consumers in Hong Kong who purchased non-heritage brand luxury products.

Table 6: Mean and standard deviation of heritage brandand non-heritage brandgroups

	Heritage Brand				Non-Heritage Brand			
	Mean		S.D.		Mean		S.D.	
	HK (n=211)	TW (n=132)	HK	TW	HK (n=90)	TW (n=53)	HK	TW
Power	3.11	3.42	0.806	0.965	3.13	3.15	0.997	1.045
Achievement	3.5	3.87	0.795	0.903	3.53	3.66	0.985	1.126
Hedonism	3.48	3.91	0.795	0.833	3.67	3.81	0.793	0.856
Stimulation	3.31	3.77	0.882	0.872	3.38	3.72	0.856	0.841
Self-direction	3.55	4.01	0.763	0.767	3.77	3.94	0.704	0.745
Universalism	3.58	3.99	0.773	0.757	3.51	3.89	0.753	0.870
Benevolence	3.57	3.96	0.75	0.725	3.67	3.81	0.703	0.810
Tradition	3.58	3.85	0.754	0.805	3.54	3.57	0.796	0.866
Conformity	3.64	3.77	0.731	0.799	3.67	3.66	0.764	0.831
Security	3.75	4.27	0.729	0.700	3.88	4.08	0.700	0.730

Table 7 shows that self-direction (F value = 5.568) is the most important dimension of person values that causes consumers in Hong Kong to select heritage brand luxury products and tradition (F value = 4.453) is the most important dimension of personal values that causes consumers in Taiwan to purchase heritage brand luxury products.

Table 7: Tests of equality of group means (heritage brand and non-heritage brand)

	HK				TW			
	Coefficients	Wilks' Lambda	F	Sig.	Coefficients	Wilks' Lambda	F	Sig.
Power	-0.011	0.999	0.050	0.824	0.707	0.985	2.732	0.100
Achievement	-0.097	0.999	0.110	0.741	-0.038	0.990	1.781	0.184
Hedonism	0.504	0.989	3.357	0.068	-0.048	0.997	0.513	0.475
Stimulation	-0.320	0.999	0.349	0.8555	-0.335	0.999	0.118	0.732
Self-direction	0.780	0.82	5.568	0.019*	-0.172	0.999	0.269	0.604
Universalism	-0.721	0.998	0.483	0.488	-0.141	0.996	0.675	0.412
Benevolence	0.214	0.997	1.002	0.318	0.043	0.992	1.529	0.218
Tradition	-0.202	0.999	0.159	0.690	0.785	0.976	4.453	0.036*
Conformity	-0.236	1.000	0.056	0.813	-0.201	0.997	0.635	0.427
Security	0.425	0.993	2.020	0.156	0.381	0.984	2.931	0.089

The results of this study indicated that consumers in Hong Kong and Taiwan perceived different person values for brand choice. Therefore, luxury brand marketers should employ different marketing strategic to promote their luxury products in Hong Kong and Taiwan.

REFERENCES

1. Economist Intelligence Unit (2014), Rich pickings: Asia to drive luxury growth, despite slowdown.
2. Vinson, D., J. Scott, et al. (1977). "The role of personal values in marketing and consumer behaviour." The Journal of Marketing **41**(2): 44-50.
3. Pitts, R. and A. Woodside (1983). "Personal value influences on consumer product class and brand preferences." Journal of Social Psychology **119**: 37-53.
4. Dubois, B. and P. Duquesne (1993). "The market for luxury goods: income versus culture." European Journal of Marketing **27**(1): 35-44.
5. Nueno, J. and J. Quelch (1998). "The Mass Marketing of Luxury." Business Horizons(November - December): 61-68.
6. Wong, A. and J. Zaichkowsky (1999). "Understanding luxury brands in Hong Kong." European Advances in Consumer Research **4**: 310-316.
7. Phau, I. and G. Prendergast (2000). "Consumer luxury brands: the relevance of the "rarity principle"." Journal of Brand Management **8**(2): 122-138.
8. Vigneron, F. and L. Johnson (2004). "Measuring perceptions of brand luxury." Journal of Brand Management **11**: 484-506.
9. Wiedmann, K., N. Hennings, et al. (2007). "Measuring consumers' luxury value perception: a cross-cultural framework." Academy of Marketing Science Review **7**: 1-21.
10. Godey, B., D. Pederzoli, et al. (2011). "Brand and country-of-origin effect on consumers' decision to purchase luxury products." Journal of Business Research: 1-10.
11. Li, G., G. Li, et al. (2012). "Luxury fashion brand consumers in China: perceived value, fashion lifestyle, and willingness to pay." Journal of Busines Research **65**: 1516-1522.
12. Thakor, M. and A. Lavack (2003). "Effect of perceived brand origin associations on consumer perceptions of quality." Journal of Product & Brand Management **12**(6): 394-407.
13. Nueno, J. and J. Quelch (1998). "The Mass Marketing of Luxury." Business Horizons(November - December): 61-68.
14. Beverland, M. (2004). "Uncovering "the theories in-use": building luxury wine brands." European Journal of Marketing **38**(3/4): 446-466.
15. Moore, C. and G. Birtwistle (2005). "The Burberry business model: creating an international luxury fashion brand." Intenational Journal of Retail & Distribution Management **32**(8): 412-422.
16. Kent, C., S. Macdonald, et al. (2000). Luxury status, achieving and exploiting it. November Industry REport. M. S. D. Witter.

17. Beverland, M. (2004). "Uncovering "the theories in-use": building luxury wine brands." European Journal of Marketing **38**(3/4): 446-466.

18. Okonkwo, U., Ed. (2007). Luxury Fashion Branding. Hampshire, Palgrave Macmillan

19. Thakor, M. and A. Lavack (2003). "Effect of perceived brand origin associations on consumer perceptions of quality." Journal of Product & Brand Management **12**(6): 394-407.

20. Doyle, P. (1990). "Building successful brands: the strategic options." The Journal of Consumer Marketing **7**(2): 5-20.

21. Moore, C., J. Fernie, et al. (2000). "Brands without boundaries - the internationalisation of the designer retailer's brand." European Journal of Marketing **34**(8): 919-937.

22. Lee, A. (2002). "Effects of implicit memory on memory-based versus stimulus-based brand choice." Journal of Marketing Research(November): 440-454.

23. Van Rij, J. (1996). "Trends, symbols and brand power in global markets: the business anthropology approach." Strategy & Leadership **24**(Nov/Dec): 18-24.

24. Fionda, A. and C. Moore (2009). "The anatomy of the luxury fashion brand." Brand Management **16**(5/6): 347-363.

25. O'Cass, A. and H. Frost (2002). "Status brands: examining the effects of non-product-related brand association on status and conspicuous consumption." The Journal of Product and Brand Management **11**(2/3): 67-86.

26. Urde, M. (2007). "Corporate brands with a heritage." Brand Management **15**(1): 4-19.

27. Menkes, S. (2010). Heritage luxury: past becomes the future. New York Times. New York.

28. Merchant, A. and G. M. Rose (2012). "Effects of advertising-evoked vicarious nostalgia on brand heritage." Journal of Business Research: 1-7.

29. Homer, P. and L. Kahle (1988). "A structural equation test of the value-attitude-behaviour hierarchy." Journal of Personality and Social Psychology **4**: 638-646.

30. Vinson, D., J. Scott, et al. (1977). "The role of personal values in marketing and consumer behaviour." The Journal of Marketing **41**(2): 44-50.

31. Pitts, R. and A. Woodside (1983). "Personal value influences on consumer product class and brand preferences." Journal of Social Psychology **119**: 37-53.

32. Lai, A. W. (1995). "Consumer Values, Product Benefits and Customer Value: A Consumption Behavior Approach." Advances in Consumer Research **22**: 381-388.

33. Schwartz, S. and L. Sagiv (1995). "Idintifiying culture-specific in the content and structure of values." Journal of Cross Cultural Psychology **26**(1): 92-116.

34. Bardi, A. and S. Schwartz (2003). "Values and behaviour: strength and structure of relations." Personality and Social Psychology Bulletin **29**: 1207-1220.

35. Homer, P. and L. Kahle (1988). "A structural equation test of the value-attitude-behaviour hierarchy." Journal of Personality and Social Psychology **4**: 638-646.

36. Schwartz, S. and W. Bilsky (1987). "Toward a universal psychological structure of human values." Journal of Personality and Social Psychology **53**(550-562).

37. Linderman, M. and M. Verkasalo (2005). "Measuring values wth the short Schwartz's Value Survey." Journal of Personalilty Assessment **85**(2): 170-178.

SUSTAINABLE DEVELOPMENT: AN EDUCATIONAL PERFORMANCE MEASURES UNDER UNCERTAINTY

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ABSTRACT

Purpose: The purpose of this paper is to investigate interesting developments on how sustainability issues have been integrated into the performance measures of Technological and vocational education (TVE) in Taiwan under uncertainty.

Design/methodology/approach: In this paper, the authors present modified balanced scorecard (BSC) model and practices the expert perceptions by applied fuzzy Delphi method and fuzzy performance score in evaluating the performance of TVE in Taiwan. Two top private and national universities of science and technology are decided to develop and determine the weights of BSC aspects and attributes (activities, components, and characteristics) in the solution of their organizational performance.

Findings: TVE has an important role in Taiwan's national development. TVE cultivates numerous professional and technical workforces; it not only provides a firm and positive foundation for Taiwan's economic development but also facilitates industries to move into the international arena. This vision of an elaborative TVE integrates even more resources to synchronize the institutional infrastructure with the market demand in workforces to enhance the quality of education. In addition, this is practical teaching and applicable knowledge which is encouraging students with advanced technical skills to apply to their career.

Practical implications :The management was thinking of evaluating the performance measurement by a valid BSC model. The proposed hybrid approach is presented. The management expects that the hybrid approach helps the universities understand their performance and thus, to deal with future challenges.

Originality/value :This study adopts modified balanced scorecard model and practices the expert perceptions by applied fuzzy Delphi method and fuzzy performance score in evaluating the performance of TVE in Taiwan, and provides evidences that the measures are of particular importance for future research and higher education for sustainable development.

Keywords: Sustainability, technological and vocational education, balanced scorecard, fuzzy Delphi

Classification: Conceptual paper

INTRODUCTION

Technological and Vocational Education (TVE) has played an important role for long-term progress and industrial development in Taiwan. This educational development tightly intertwines with the direction of industries and human resource needs. TVE's higher education produced massive quantity of fundamental- and intermediate-level of technical and research & development (R&D) professionals to meet the industrial demands. Recent years, the government begins to promote TVE to push the six emerging, four smart, ten service industries, in order to induce R&D innovation, increase the value of industries, and strengthen the competiveness of services sectors. TVE cultivates practical professionals according to their aptitudes and capabilities, so that contributes to those industries. In addition, another emphasis is on industrial-academic cooperation, which aims to provide students, internships to practice talents, employment upon graduation and excel at work. This is a win-win situation to achieve in practical teaching and increasing competitiveness (MOE, 2011). This study proposes to identify the missing link between industrial-academic perceptions. Moreover, there are stakeholders and sustainable development (SD) issues involved for the SD of TVE institutions. Still, there are limited literatures on developing a set of attributes and stakeholders for the institutions.

SD ties together concern for the carrying capacity of natural systems with the social and economic challenges. Hence, to prioritize the SD attributes are considering being environmental sustainability over economic and social perspectives (Dyllick and Hockerts, 2002). It argues to provide a set of contextual model to improve overall sustainability where cutting edge SD is unattainable (DeSimone, L., Popoff, 1997; Stavins et al., 2002; Reed et al., 2006). Hence, there is a need for an efficient and accurate model serves as tool to control, monitor and improve their processes and performance. In lieu of this, Kaplan and Norton (1992; 1996) proposed balanced scorecard (BSC) model to assess the performance using financial and non-financial indicators. The model is to express the indicators of performance

assessment and requires for the assessment in the stakeholders and management functions. Moreover, the model contains qualitative and quantitative information among the four aspects and attributes in the organization. The existing literatures are lacking to address SD issue in the assessment.

In the stakeholders view, the stakeholders and the organization have a binding fiduciary duty to meet needs and to increase values in networks. Hence, the stakeholder theory argues that there are other parties involved, including faculties, employees, customers, industrial practitioner, policy makers etc. (Laplume et al., 2008). Even competitors are counted as stakeholders and their status being derived from their capacity to affect the firm and its stakeholders (Freeman, 1984; Friedman, Miles, 2002). Carter and Rogers (2008) presented that the sustainability as the strategic integration and achievement of an organization's social, environmental and economic goals in the systemic coordination of internal business processes for improving the long-term performance and stakeholders. Most of these organizations realize that, in order to evolve an efficient and effective SD, which needs to be assessed for its performance (Tseng et al., 2009; Tseng, 2013). The traditional BSC model is only focusing on internal business process, learning and growth, customers and financial aspects, which didn't include the stakeholders and SD concept. Hence, this study proposes the model aspects has to be internal business process, learning and growth, stakeholders and sustainability due to the stakeholder theory, SD and Kaplan and Norton's BSC model are involved for this specific assessment.

However, to deal with qualitative and quantitative information, quantitative information is expressed numerically and qualitative is a form of data collections that gathers information in linguistic preferences. As usual, human beings are constantly making decisions under linguistic preferences. The preferences are uncertain and decision-makers might be reluctant or unable to assign exact numerical values to compare their judgments due to the aspects and attributes are subjective and qualitative in nature (Dong et al., 2008; Tseng et al., 2009; Tseng, 2013). In this situation, it is more desirable to apply fuzzy assessment. Fuzzy set theory resembles human reasoning in its use of approximate information and uncertainty to generate decisions. This method adequately overcomes the ambiguity of concepts associated with human being's subjective judgments. Hence, these two types' scales need to transform into comparable scales. In addition, to arrive the modified BSC model, the fuzzy Delphi method is applicable for verifying the assessing attributes (Hsu et al., 2011). The performance score is evaluated through to resolve the importance and performance levels together in complex environment (Lin et al., 2013; Tseng et al., 2013).

Hence, the aim of this study is to propose the concept of SD assessment and stakeholder theory into modified BSC model with qualitative and quantitative information. Hence, SD leads to a long-term strategic role in achieving the social, environmental, and economic performance and contributing to SD literatures. The contribution is to present and organize the modified BSC model with stakeholders' consideration in assessing the TVE in Taiwan. The paper is organized as follows. This study provides a BSC model assessment of how is the role of BSC model in the SD and reviews the literature on the aspects and attributes of this study in session 2. The section 3 presents the method and the data analysis. To arrive the study objective, this utilizes data from an expert linguistic preference questionnaire survey of the professionals in Taiwanese TVE. The data were then analyzed using fuzzy Delphi method and fuzzy performance score. The results are discussed in session 4. This discussion is a modified BSC model under uncertainty. The last section presents the discussion, implications, contributions and limitations and conclusions.

LITERATURE REVIEW

There are two major perspectives in BSC model, those are the numerical and non-numerical indicators from operations and the view of BSC model is to effectively integrate between the two perspectives. This section examines the BSC model for SD and four aspects and attributes of this study are discussed.

Sustainable development

The SD principle needs a strong political engagement because of the constant need to seek equilibrium between economic, environmental and social concerns (Ahi and Searcy, 2013). SD in education underlines the promotion of values and behaviors in line with principles. Instead, it means teaching and learning about the concept itself, stakeholders (employees, faculties, community, policy-makers etc.) and SD concept, and thus, to include the resources of the industrial needs (Milutinović and Nikolić, 2014). It recognized while challenging and insightful theoretical analyses abound, and much supportive rhetoric can be found in governmental policy and aspirations, multilateral agencies and private sector statements. Moreover, SD requests more efficient and accurate performance measurement model serves as useful tools that enable management to control, monitor and improve their internal business processes and performance. Recently, there are abundant SD studies focusing on education.

In prior studies, Grinsted (2011) showed that the contribution to the emerging consensus on the university's role and function in relation to SD. Crossley and Sprague (2013) focused

on how education may contribute to sustainable development in small state contexts upon the challenges of climate change and economic recession. Milutinović and Nikolić (2014) presented the debates on the appropriate and desirable to accelerate the efforts on internal integration of universities and assess the current developments in theory and practice of higher education for SD, and possible implications on higher education practice. Though, prior studies provided evidences of an increasing focus on incorporating the concepts of sustainability by higher education institutions into research and operations, globally (Fien, 2002; Lozano, 2010; Karatzoglou, 2013). Thus, this assessment needs to give precedence on those SD attributes, critical thinking, personal choices through proper contents and interdisciplinary. However, the SD approach in education is currently lacking a systematic framework to approach the performance of SD.

Balanced scorecard

The BSC presents the performance measurement approaches in management control. The aspects integrated the stakeholders on a scoreboard. The financial indicators that use performance measures have been criticized as inadequate for the rapidly changing environment, especially when the sustainable issues are the main sources of building competitive advantage for SD. These attributes include stakeholder satisfaction, internal process integration, social expectation/ reputation etc. To overcome the limitations of traditional financial-based measures and non-financial measures for SD, this study has been recommended owing to traditionally be believed the leading indicators of financial performance.

In the literatures, Kaplan and Norton (1996) contended that in the BSC program a cause-and-effect relationship exists between the financial and non-financial aspects. BSC combined important practices and concepts from various disciplines and theories into a single performance measurement system to improve performance. Cebeci (2009) proposed that a decision support system integrated with strategic management by using the BSC model to ERP selection. The essence of traditional BSC lies in seeking critical attributes between financial and non-financial measures. Wang et al. (2010) presented a hierarchical BSC model to solve the degree of interaction between performance perspectives and corresponding performance indicators. Tseng (2010) proposed a fuzzy network hierarchical BSC model to deal with the interactive and interdependence among the aspects and attributes to obtain the weights of measures.

Unfortunately, those approaches might hold drawbacks and pitfalls in the model application. First of all, these techniques did not consider on how the attributes are

maintaining in the proposed BSC model. Secondly, with a BSC model, they could not determine simultaneously the integrated degree of performance and importance levels between the various aspects and attributes through their proposed methods. Thirdly, the traditional BSC model is inadequate to involve more stakeholder and SD corresponding quantitative and qualitative attributes together. Hence, the modified BSC model is proposed.

The measures

In traditional BSC model, the financial performance can be improved by focusing on learning and growth, internal processes and customer aspects. In addition, SD is a strategic integration for increasing effectiveness and for better realization of organizational goals to enhance competitiveness (Alshuwaikhat and Abubakar, 2008). Lambert et al. (2006) stated that "*the integration of key business processes from end-user through original suppliers, that provides products, services, and information that add value for customers and other stakeholders*". Moreover, the stakeholders are the related groups and have binding fiduciary duties to place their roles, then to increase value for the organization. It involved employees, customers, suppliers and other related groups involved. Hence, broaden the stakeholder's concept (Friedman and Miles, 2002), this study would propose BSC model as learning and growth, internal operations, stakeholders and sustainability, four aspects with SD concept.

In addition, SD needs to develop a strategic plan, integration, friendly environment and achievement of an organization's social, environmental and economic goals in the systemic coordination of internal processes for improving the long-term performance (Alshuwaikhat and Abubakar, 2008). Tang and Zhou (2012) observed that environmental dimension included the consumption of natural resources and the emission of waste and pollution, while stakeholder aspects are related to customers and employees etc. Assessing the literature's usage of the sustainability dimensions into BSC model in greater detail, e.g. which metrics are suitable to represent sustainability factors and which attributes are taken in holistic performance framework, would identify what avenues exist to further integrate holistic measures and the resulting performance impacts.

The aspect of sustainability is about the organization working towards profit maximization within the ambit of the laws and ethics, being socially responsible and responsive to the society. However, profitability is not a major advantage associated with sustainability. For instance, implementing SD (corporate social responsibility, CSR) activities build a well reputation and enhance employees' commitment, morale, and productivity from an internal business process (Hodgson, 2005; Barth et al., 2011). Also, the management support for environment is always including in monitoring the collaborative planning,

forecasting and replenishment with multi-stakeholders. Hence, increasing the competitive advantage is by being proactive in SD. In this context, firms have to integrate sustainable practices in the management of stakeholders.

The internal operations, the TVE focuses on learning-by-doing and practical learning principles as an important pre-condition for better adjustment to industrial needs. Tseng et al. (2009) pointed out that firms have begun to use environmental, health and safety and social indicators to improve their environmental practices. An organization's ability to provide a safe environment for workers is comprised of several attributes including, obtaining zero lost workdays due to work-related injuries and illnesses, increasing the rate of employee suggested improvements in innovation, social and environment health and safety performance, improving employee training on SD knowledge, and increasing employee well-being and job satisfaction (Wals and Jickling, 2002; Lidgren et al., 2006; Clarke and Kouri, 2009).

Learning and growth aspect is an important intangible component of BSC model. It is related to internal operations and therefore to stakeholders and sustainability. This aspect serves as basis for the management (Weenen, 2000). The management is really difficult to perform effective means that would improve performance of people and internal operations. The firms have agreed that employee/faculty/customer satisfaction is a precondition for overall success. There are ways to improve employee satisfaction, retention and productivity (Wright, 2002; Tseng et al., 2013). Learning and growth success is the sources of enablers for employee, information systems and organizational alignment in SD (Haake and Seuring, 2009).

Aforementioned, the proposed modified BSC model (aspects and attributes) integrated from the relevant literatures. The activities, components, and characteristics that are found to be associated with this evaluation framework are put forward as modified BSC model attributes (See Table 1). Table 1 presents the BSC aspects and attributes.

Table 1. The initial BSC model

Aspects	Attributes
Sustainability (AS1)	Annual growth in revenue (C1)
	Cost of revenue: extent that it remains flat or decreases each year (C2)
	Profit margin: return on total capital employed (C3)
	Growth from new services/ educational departments (C4)
	Industry leadership: market share (C5)
	Academic reputation and image (C6)
	Encouraging to be environmentally friendly in the property (C7)
	Industrial oriented educational program (C8)
	Internationalization in campus (C9)
	Encourage stakeholders to participate in SD initiatives (C10)
	Strategic plan for SD (Economics, environment and social) (C11)
	Reduce carbon emissions (C12)
	Recycle/Reuse/Reduce resources (C13)
Stakeholders (AS2)	Student retention/percentage of growth with existing students (C14)
	Student acquisition: number of new students /total revenue to new students (C15)
	Student satisfaction (via satisfaction surveys) (C16)
	Industrial professional lectures (C17)
	Service quality: student complain rates (C18)
	University funding supports eg. Trustees, government etc. (C19)
	Internship program providers (C20)
	International collaborators (C21)
	Industrial collaborators (C22)
	Faculties with industrial experiences (C23)
	Policy makers eg. Government, management levels etc. (C24)
	Harmonize with local communities eg. Associations etc. (C25)

Aspects	Attributes
Internal operations (AS3)	Service cycle processing time (C26)
	Cost of service quality comparison (Other institutions) (C27)
	Reduce service costs: service costs as percentage of revenue (C28)
	Service output per hour/facilities utilization (C29)
	Environmental safety incident index (C30)
	Social responsibility promotions (C31)
	Award programs for faculties /Employee/Students (C32)
	Student bridging educational programs to Industry (learning-by-doing) (C33)
	Friendly environment for International students (C34)
	International education programs/collaborations(C35)
	Friendly approach to university information (C36)
	One stop-shop policy for students/faculties solutions(C37)
	Investment to university structural and infrastructural (C38)
	Certified programs and Certificates eg. AACSB, ISO9001, ISO14001 IEET etc. (C39)
Learning and growth (AS4)	Innovation of educational program (C40)
	Rate of new services/educational package introduction per year (C41)
	Enhance Faculties /Employee capabilities eg. Continuous education programs (C42)
	Faculties /Employee satisfaction survey (C43)
	Faculties /Employees awareness on SD (Economics, environment and social) (C44)
	Faculties /Employee retention: percentage of key staff turnover (C45)
	Number of promotions from internal organization (C46)
	Absenteeism rate for Faculties /Employee (C47)
	Student learning and growth activities after classes eg. Clubs, teams etc. (C48)
	Faculties /Employees turnover rate per year(C49)
	Student achievements eg. Licenses, competitions awards, internship etc. (C50)
	Faculties /Employees achievements eg. awards, career development etc. (C51)
	Encourage learning and growth program for faculties /employees(C52)

METHOD

To determine the assessment, the aspects and attributes are structured in BSC model with qualitative and quantitative approaches. The proposed methods and proposed solution steps are described below.

Transformation of the quantitative data

The crisp values from the measures are characterized by various units. The various units cannot be compared, directly. The crisp values must be normalized to achieve unit-free and therefore comparable. The normalized crisp values of C_{ij} are calculated using equation (1) (Chen and lin, 2002; Tseng *et al*., 2009b).

$$C_{ij} = \left(c_{ij}^N - \min c_{ij}^N\right)/\left(max\, c_{ij}^N - \min c_{ij}^N\right) X_{ij} \in (0,1); N = 1,2,\dots n \tag{1}$$

where $\max C_{ij}^N = \max\{c_{ij}^1, c_{ij}^2, \dots c_{ij}^N\}$ and $\min C_{ij}^N = \min\{c_{ij}^1, c_{ij}^2, \dots c_{ij}^N\}$

Fuzzy Delphi method

FDM proposed by Ishikawa et al. (1993), and derived from the traditional Delphi technique and fuzzy set theory. Noorderhaben (1995) presented the FDM to group decision to solve the fuzziness of common understanding of expert perceptions. The efficiency and quality of questionnaires could be improved. Assuming the value of the significance of no. j element given by no. i experts is $\tilde{a} = (l_{ij}, m_{ij}, u_{ij})$, i=1,2,3,….n; j=1,2,3,….m. The weighting $\tilde{a}_j$ of no. j element is $\tilde{a}_j = (l_j, m_j, u_j)$, which $a_j = min\{l_{ij}\}$, $b_j = (\prod_1^n m_{ij})^{1/n}, c_j = max\{u_{ij}\}$. Table 2 displays the linguistic scales and the TFNs for intangible linguistic scales in which the terms are defined (Tseng, 2010).

Table 2. Linguistic scales

Linguistic terms (Performance/Importance)	(TFNs)
Extreme	(0, 0.1, 0.3)
Demonstrated	(0.2, 0.3, 0.5)
Strong	(0.3, 0.5, 0.7)
Moderate	(0.5, 0.7, 0.9)
Equal	(0.7, 0.9, 1.0)

Note: this table is the linguistic scale and corresponding TFN (Wang and Chang, 1995 and Chen, 1996)

Using convex combination method, the H is presented as follows:

$$H = \int (u_{ij}, l_{ij}) = \lambda[u_{ij} + (1-\lambda)l_{ij}]$$
$$\begin{cases} u_{ij} = u_{ij} - \alpha(u_{ij} - m_{ij}) \\ l_{ij} = l_{ij} - \alpha(m_{ij} - l_{ij}) \end{cases} \tag{2}$$

The α- method is a finite set $[0,1]$, represents the from optimistic to pessimistic on the specific objects, using Eq. (3) to acquire the definite value is obtained $\tilde{R}_j$

$$\tilde{R}_j = \lambda[u_{ij} + (1 - \lambda)l_{ij}] \tag{3}$$

The proper attributes can be screened out from numerous attributes by setting the threshold value (δ). The following rules are applied for the attributes whether accepted or unaccepted. If $\tilde{R}_j \geq \delta$ the no. j criterion is accepted for evaluation attributes; and if $\tilde{R}_j < \delta$ then the attribute is unaccepted.

Fuzzy set theory

A fuzzy set $\tilde{A}$ in a universe of discourse X is characterized by the membership function $\mu_{\tilde{A}}(x)$ that assigns each element x in X a real number in the interval [0, 1]. The numerical value $\mu_{\tilde{A}}(x)$ stands for the grade of membership of x in $\tilde{A}$ (Braae and Rutherford, 1978; Wu et al., 2012). Table 1 presents the corresponding interval-valued TFNs with linguistic preferences.

Definition. A TFN $\tilde{a}$ is defined by a triangular $\tilde{a} = (l, m, u)$ with membership function

$$\mu_{\tilde{A}}(x) = \begin{cases} 0, & x < l \\ (x - l)/(m - l), & m \geq x \geq l \\ (u - x)/(u - m), & m \geq x \geq u \\ 0, & otherwise \end{cases} \tag{4}$$

The TFN is based on a three-value judgment: the minimum possible value l, the mean possible value m and the maximum possible value u. The attribute values depend on linguistic preferences.

Let M_{ij} be the importance weighted value of perspective i and criterion j. The membership function of TFN $M_{ij} \in S$. Let P_{ij} be the performance value of perspective i and criterion j. The membership function of TFN is $P_{ij} \in T$.

$$M_{ij}^n = \left(wl_{ij}^n, wm_{ij}^n, wu_{ij}^n\right), M_{ij} \in S, where \; 0 \leq wl_{ij} \leq wm_{ij} \leq wu_{ij} \leq 1 \tag{5}$$

$$P_{ij}^n = \left(pl_{ij}^n, pm_{ij}^n, pu_{ij}^n\right), M_{ij} \in T, where \; 0 \leq pl_{ij} \leq pm_{ij} \leq pu_{ij} \leq 1 \tag{6}$$

where M_{ij} are the value of respondents for perspective i and criterion j and the expert

weights in the evaluation, respectively. The output of the fuzzy system is a fuzzy set, the defuzzification procedure is to convert the fuzzy results into crisp values. The center-of-area yields better results than the mean of maximum. The center-of-area is a simple and practical method for calculating best non-fuzzy performance (BNP) values (Lin et al., 2013). Eqs. (7) and (8) determine the BNP values of the fuzzy weights.

$$\text{BNP}_i^w = [(wu_{ij}^n - wl_{ij}^n) + (wm_{ij}^n - wl_{ij}^n)]/3 + wl_{ij}^n \,, \forall_i \tag{7}$$

$$\text{BNP}_i^p = [(pu_{ij}^n - pl_{ij}^n) + (pm_{ij}^n - pl_{ij}^n)]/3 + pl_{ij}^n \,, \forall_i \tag{8}$$

Lastly, the Final Performance Score (FPS) is calculated with Eqs. (7) and (8). Where n is the number of aspect or attributes.

$$\text{FPS} = (\sum \text{BNP}_i^w \times \text{BNP}_i^p)/n \tag{9}$$

Proposed approach

This study attempts to apply FDM and FPS to the evaluation of aspects and attributes in TVE for SD. The study objective is to analyze how the proposed hybrid method can be used to rank the aspect and attributes in BSC model. The expert group followed the five steps proposed approach for solution.

1   Identifying BSC aspects and attributes - the stakeholders are involved in SD of educational institutes. This assessment is necessary to form an expert team to achieve the study objective.
2   The BSC model composes qualitative and quantitative information from the aspects and attributes. Transform the quantitative data into comparable scale, Eq (1). There are several attributes gathered from the two top private and national universities of science and technology. Hence, the FDM is employed to eliminate part of the attributes based on the expert opinions, using Eqs. (2) and (3). The threshold value is computed for expert validity.
3   Using Eq. (4) to justify the membership function of TFN, applied Eqs. (5)-(8) to compute the performance and importance weighting scores. This approach applied the final performance score (FPS), applied Eq. (9), to integrate the perceptions on the performance and importance levels together.
4   The FPS is calculated and compares the differences between two universities of science and technology in perceptions of industrial and academic focuses.

BACKGROUND

TVE has an important role in Taiwan's national development. TVE cultivates numerous professional and technical workforces; it not only provides a firm and positive foundation for Taiwan's economic development but also facilitates industries to move into the international arena. As times change, it needs to cultivate professional skills, strengthen social responsibility and professionalism in students in order to bring forth their commitment to business and workplace ethics. This vision of an elaborative TVE integrates even more resources to synchronize the institutional infrastructure with the market demand in workforces to enhance the quality of education. In addition, this is practical teaching and applicable knowledge which is encouraging students with advanced technical skills to apply to their career. Recent years, the TVE faces more challenges due to the educational programs have missing link with the industrial human resources needs. Hence, this study approaches to two top private and national universities of science and technology to evaluate their performance through ten industrial practitioners and ten professors from the institutions.

Two top private and national universities of science and technology are decided to develop and determine the weights of BSC aspects and attributes in the solution of their organizational performance. However, these were its reasons: first, the universities continued to improve their operations processes and faced a challenge regarding how to manage the BSC model in the competitive environment. Second, the universities had to sustain reform as its performance measurement in order to deal with intensive competitions. The management was thinking of evaluating the performance measurement by a valid BSC model. The proposed hybrid approach is presented. The management expects that the hybrid approach helps the universities understand their performance and thus, to deal with future challenges. The expert team has to be familiarized with the evaluation BSC model of the case background. The expert team also needed to full knowledge of this approach to the modified BSC model. The role of the team is to act as a performance system integrator by developing a total approach solution.

REFERENCES

1. Ahi, P., and Searcy, C. (2013), "A comparative literature analysis of definitions for green and sustainable supply chain management", *Journal of Cleaner Production*, Vol. 52, pp.329-341.

2. Alshuwaikhat, H., and Abubakar, I. (2008), "An integrated approach to achieving campus sustainability: assessment of the current campus environmental management practices", *Journal of Cleaner Production*, Vol. 16 No.16, pp1777-1785.

3. Barth, M., Adomßent, M., Albrecht, P., Burandt, S., Godemann, J., Franz-Balsen, A., and Rieckmann, M. (2011), "Towards a 'Sustainable University': scenarios for sustainable university development", *International Journal of Innovation and Sustainable Development,* Vol. 5 No. 4, pp. 313-332.

4. Braae, M., and Rutherford, D. A. (1978), "Fuzzy relations in a control setting", *Kybernetes*, Vol. 7 No. 3, pp. 185–188.

5. Carter, C.R., and Rogers, D.S. (2008), "Sustainable supply chain management: toward new theory in logistics management", *International Journal of Physical Distribution and Logistics Management*, Vol. 38 No. 5, pp. 360–387.

6. Cebeci, U. (2009), "Fuzzy AHP-based decision support system for selecting ERP systems in textile industry by using balanced scorecard", *Expert Systems with Applications*, Vol. 36, pp. 8900–8909.

7. Chen, S. M. (1996), "Evaluating weapon systems using fuzzy arithmetic operations", *Fuzzy Sets and Systems,* Vol. 77, pp. 265-276.

8. Cheng, C. H., and Lin, Y. (2002), "Evaluating the best main battle tank using fuzzy decision theory with linguistic criteria evaluation", *European Journal of Operational Research,* Vol. 142 No. 1, pp. 174-186.

9. Clarke, A., and Kouri, R. (2009), "Choosing an appropriate university or college environmental management system", *Journal of Cleaner Production,* Vol. 17, pp. 971-984.

10. Crossley, M., and Sprague, T. (2014), "Education for sustainable development: Implications for small island developing states (SIDS)", *International Journal of Educational Development,* Vol. 35, 86-95.

11. DeSimone, L., and Popoff, F. (1997), *Eco-efficiency: The business link to sustainable development*, Cambridge: MIT Press.

12. Dong, Y.C., Xu, Y.F., and Li, H.Y. (2008), "On consistency measures of linguistic preference relations", *European Journal of Operational Research*, Vol. 189 No. 2, pp. 430–444.

13. Dyllick, T., and Hockerts, K. (2002), "Beyond the business case for corporate sustainability", *Business Strategy and the Environment*, Vol. 11 No. 2, pp. 130–141.

14. Fien, J. (2002), "Advancing sustainability in higher education: issues and opportunities for research", *Higher Education Policy*, Vol. 15, pp. 143-152.

15. Freeman, R. E. (1984), *Strategic Management: A stakeholder approach.* Boston: Pitman.

16. Friedman, A.L., and Miles, S. (2002), "Developing Stakeholder Theory", *Journal of Management Studies*, Vol. 39 No. 1, pp. 1–21.

17. Haake, H., and Seuring, S. (2009), "Sustainable procurement of minor items e exploring limits to sustainability", *Sustainable Development,* Vol. 17 No. 5, pp. 284-294.

18. Hodgson, S. (2005), "Corporate social responsibility: it's compelling good business to give something back to Nigerian", *The Guardian*, Vol. 21 No. 9690, pp. 15.

19. Hsu, C.W., Hu, A.H., Chiou, C.Y., and Chen, T.E. (2011), "Using the FDM and ANP to construct a sustainability balanced scorecard for the semiconductor industry", *Expert Systems with Applications*, Vol. 38 No. 10, pp. 12891-12899.

20. Ishikawa, A., Amagasa, M., Shiga, T., Tomizawa, G., Tatsuta, R., and Mieno, H. (1993), "The max–min Delphi method and fuzzy Delphi method via fuzzy integration", *Fuzzy Sets and Systems*, Vol. 55, pp. 241–253.

21. Karatzoglou, B. (2013), "An in-depth literature review of the evolving roles and contributions of universities to education for sustainable development", *Journal of Cleaner Production*, Vol. 49, pp. 44-53.

22. Lambert, D.M., Croxton, K.L., Garcia-Dastugue, S.J., Knemeyer, M., and Rogers, D.S. (2006), *Supply Chain Management Processes, Partnerships, Performance*, 2nd edition. Hartley Press Inc., Jacksonville.

23. Laplume, A., Karan S., and Reginald L. (2008), "Stakeholder Theory: Reviewing a Theory That Moves Us", *Journal of Management,* Vol. 34 No. 6, pp. 1152–1189.

24. Lidgren, A., Rodhe, H., and Huisingh, D. (2006), "A systemic approach to incorporate sustainability into university courses and curricula", *Journal of Cleaner Production*, Vol. 14 No. 9-11, pp. 797-809.

25. Lin, Q.L., Liu, L., Liu, H.C., and Wang, D.J. (2013), "Integrating hierarchical balanced scorecard with fuzzy linguistic for evaluating operating room performance in hospitals", *Expert Systems with Applications,* Vol. 40 No. 6, pp. 1917-1924.

26. Lozano, R., (2010), "Diffusion of sustainable development in universities' curricula: an empirical example from Cardiff University", *Journal of Cleaner Production,* Vol. 18, pp. 637-644.

27. Milutinović, S., and Nikolić, V. (2014), "Rethinking higher education for sustainable development in Serbia: an assessment of Copernicus charter principles in current higher education practices", *Journal of Cleaner Production*, Vol. 62, pp. 107-113.

28. Ministry of Education (August, 2012). "Technological and Vocational Education in Taiwan, ROC", available at http://www.studyintaiwan.org/album/v4_publications/5254f7bd7b0ec.pdf (accessed 7 February 2014)

29. Noorderhaben, N. (1995), *Strategic decision making,* UK: Addison-Wesley.

30. Reed, M.S., Fraser, E.D.G., and Dougill, A.J. (2006), "An adaptive learning process for developing and applying sustainability indicators with local communities", *Ecological economics*, Vol. 59, pp. 406-418.

31. Stavins, R.; Wagner, A.; Wagner, G.(2002). Interpreting Sustainability in Economic Terms: Dynamic Efficiency Plus Intergenerational Equity. Economic Letters 79 (3), 339–343.

32. Tang, C. S., Zhou, S. (2012). Research advances in environmentally and socially sustainable operations. European Journal of Operational Research 223, 585–594.

33. Tseng M.L. (2010). Implementation and performance evaluation using fuzzy network balanced scorecard. Computers and Education 55(1), 188-201.

34. Tseng M.L. (2013). Modeling the sustainable production indicators in linguistic preferences. Journal of Cleaner Production 40, 46-56.

35. Tseng, M.L. (2013). Modeling the sustainable production indicators in linguistic preferences. Journal of Cleaner Production 40, 46-56.

36. Tseng, M.L., Chiang, J.H., Lan, W. L. (2009). Selection of optimal supplier in supply chain management strategy with analytic network process and choquet integral. Computer and Industrial Engineering 57(1), 330-340.

37. Tseng, M.L., Divinagracia, L. Divinagracia, R. (2009). Evaluating firm's sustainable production indicators in uncertainty. Computer and Industrial Engineering 57, 1393-1403.

38. Tseng, M.L., Lin, R.J., Tan K., Geng, Y., Lim, M. (2013). Benchmarking eco-efficiency in green supply chain practices in uncertainty. Production Plan & Control (Article in press) DOI:10.1080/09537287.2013.808837

39. Wals, A.E.J., Jickling, B., (2002). 'Sustainability' in higher education: from doublethink and newspeak to critical thinking and meaningful learning. Higher Education Policy 15 (2), 121-131.

40. Wang, C.H., Lu, I.Y., Chen, C.B. (2010). Integrating hierarchical balanced scorecard with non-additive fuzzy integral for evaluating high technology firm performance. International Journal Production Economics 128, 413–426.

41. Wang, M. J. J., and Chang, T. C. (1995). Tool steel materials selection under fuzzy environment. Fuzzy Sets and Systems 72, 263-270.

42. Weenen, H., (2000). Towards a vision of a sustainable university. International Journal of Sustainability in Higher Education 1 (1), 20-34.

43. Wright, T., (2002). Definitions and frameworks for environmental sustainability in higher education. International Journal of Sustainability in Higher Education 8 (3), 203-220.

44. Wu, C. T., Tsai, H. T., Shih, M. H., Fu, H. H. (2010). Government performance evaluation using a balanced scorecard with a fuzzy linguistic scale. Service Industries Journal 30(3), 449–462.

THE FIRM-LEVEL IMPACTS OF LOCAL ACTION GROUP FUNDING TO MICROENTERPRISES

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STRUCTURED ABSTRACT

Purpose: In Europe, the public sector allocates a significant amount of resources to entrepreneurship support through subsidies and public advisory services. Typically, public entrepreneurship support is provided without any expectation of direct returns. However, there is a lack of information about the efficiency and effectiveness of these actions. Entrepreneurs in northern sparsely populated areas also face context-specific challenges as they operate in the market. The purpose of this study is to investigate the impacts of local action group funding to microenterprises in a northern sparsely populated area.

Design/methodology/approach: This is a retrospective, single-case study focusing on a sparsely populated area in Northern Finland. The study is based on 25 semi-structured enterprise interviews. Multiple perspectives are analysed in the interviews.

Findings: This study investigates what the influence was of public local rural financial support from microenterprise entrepreneurs' perspectives. As a result of this case study, the role of public business advisory services for the entrepreneurs in local rural funding process is also clarified.

Research limitations/implications: This case study is limited to case enterprises located in Northern Finland in order to get an in-depth understanding of the phenomenon.

Practical implications: Results of this study can contribute to the effectiveness of public business subsidies. Results can be used by public business support service providers to

improve their processes to correspond more effectively to case-specific needs of microentrepreneurs.

Originality/value: *Current literature provides limited information about how effectively and efficiently public entrepreneurship support promotes microenterprises.*

Category: Case study

Keywords: business advisory service, business subsidy, sparsely populated area, local action group, LAG, microenterprise

INTRODUCTION

According to the Treaty on the Functioning of the European Union, aid by a member state is prohibited. State aid is liable to distort competition in the internal market. However, some exceptions are legitimated by common interest objectives. Supporting small- and medium-sized enterprises, which play a key role in job creation and boosting economic dynamism, is seen as justified. Practically all developed economies utilize public money to provide either free or subsidized assistance to small business and the self-employed or to potential small business owners (Storey, 1998).

From the point of view of economics, subsidies should only be used to correct market failures or inefficiencies (Koski and Pajarinen, 2013a). The first argument of subsidies, according to Koski and Ylä-Anttila (2011), is that financial markets may not be able to allocate capital for the best interests of society. This may be due, for example, to asymmetric information between enterprise needs funding and the financier. Enterprise knows a lot more about projects than the financier, for whom obtaining that information can be expensive or impossible. This kind of market failure relates mainly to small-scale projects of small businesses. Another argument is that the externalities, such as an enterprise's research, will also benefit other companies. For this additional value obtained by other companies, the project's returns exceed the private returns (Koski and Ylä-Anttila, 2011).

As well, in Finland, enterprises are supported by a number of policy sectors in many different ways and via a number of instruments. Public support providers allocate direct grants, loans, guarantees and tax benefits as well as a wide range of different types of information and expert and advisory services to enterprises. The impacts of the support system are of very great interest. There is continuing debate on the need for, diversion of and the efficiency and effectiveness of enterprise subsidies and public business services. The public business support system is one of the important expressions of innovation policy, which should promote research, development, innovation and entrepreneurship. The system can be seen as part of developing the country's competitiveness. According to the European Commission's Innovation Union Scoreboard 2013, Finland is one of the "Innovation leaders"

in the EU, along with Denmark, Germany and Sweden. The performance of those countries is well above that of the EU27 average (European Commission, 2013). On the other hand, the difficult economic situation, a deficit in Finland's budget and the need to focus on the most effective subsidies require a critical evaluation of the support system and the various forms of assistance (Aaltonen *et al.,* 2013).

Finland has a bank-centred economy where banks play an important role in financing enterprises. A large proportion of microbusinesses use only one bank (Enterprise Finance Survey, 2012). Private venture capital markets are young and poorly internationalized. According to Rautio (2009), the number of private equity investors, business angels and other start-up and seed-stage investors, as well as fund investments, is small, and as a result, there is a short supply of financing. Finland's remote location and the small size of its capital market reduce foreign investors' interest in the market (Rautio, 2009).

Problems with the availability of financing are more common with small businesses; the financial problems of microenterprises with fewer than ten employees are as much as three times greater than those of large companies (Enterprise Finance Survey, 2012). Private financial sector failures exist from early stage financing until the IPO stage. In addition, venture capital investments are concentrated in rather narrow business sectors mainly engaged in high technology products and services (Puttonen and Kähönen, 2010). Only about 5% of microenterprises are well familiar and only about 20% are well or fairly familiar with the financing options and instruments offered by venture capitalists (Enterprise Finance Survey, 2013).

The capital markets are small, and there is a shortage of liquidity. Thus, public resources are used to addresses the market shortfalls that may distort the operation of the financial markets and slow down development (Rautio, 2009). The task of the public sector is to respond to problems of companies with support actions. Over the years, the enterprise support system has expanded to cover a large number of different types of instruments and organizations, both at national and regional levels (Koski and Ylä-Anttila, 2011).

The challenges of the availability of private funding are highlighted in northern sparsely populated areas. Enterprises in these areas face context-specific challenges as they operate in the market. Their remote position, long distances within areas and long distances to the markets mean additional costs for communications, logistics and transport. Local and neighbouring markets are not always large enough to ensure the profitability of enterprises. During winter, the cold, dark climate also creates special challenges such as extra costs for heating and lighting and for keeping roads and waterways in working condition. According to Ponnikas *et al.* (2014), rural areas are dominated by forests and swamps and are located far from large centres. Urban areas are few, and there may be large, uninhabited spaces between them.

Employment in these sparsely populated and rural areas has traditionally been dependent on export-oriented primary production and on an increasing public sector. In the case of Sweden and Finland, neither the forest and agricultural sectors nor the manufacturing industry are likely to recur as the important employers they were earlier (Lundmark, 2006). According to Ponnikas *et al.* (2014), in northern sparsely populated and rural areas, the population has decreased, but at the same time, the unemployment rate is high. The local economic structure is unilateral, but the importance of the service sectors has increased at the same time that the number of workplaces in primary production has declined. The relative share of employment in primary production increases the farther away one proceeds from urban centres and regional centres to rural areas.

Because of this changed structure and the decay of the traditional labour market in northern sparsely populated areas, setting up a market for small and medium sized enterprises and creating a new labour market is especially important. The vast majority of enterprises in rural areas are small microenterprises. Few enterprises in rural areas tend to increase their operational activities, but they are important sources of employment (Ponnikas *et al.* 2014).

Rural development is also an important policy area in the European Union. One essential support approach is LEADER, funded by the European Union Community Initiative Programme. Leader, meaning, "Links between the rural economy and development actions", is a local development method which allows local actors to develop rural areas by using its local development potential. The program is implemented by local action groups (LAGs). The Leader approach has a long history and has evolved over a period of 20 years, growing to become a mainstream method of European rural development. One of the regional development tools of LAGs are business subsidies to local entrepreneurs. The target group for LAGs' business subsidies consists of small, micro-sized businesses that are starting or developing.

The aim of this study is to investigate the firm-level impacts of local action group funding to microenterprises in northern sparsely populated case area from the entrepreneur's perspective. The second objective of this study is to clarify the role of public business advisory services concerning the application and funding processes of subsidies granted by LAG. These mentioned aims can be summarized in the following research questions:

(RG1)   What is the impact of rural funding on microenterprises, from the entrepreneur's perspective?

(RG2)   What is the role of public business advisory services for the entrepreneurs in the local rural funding process?

These questions were studied by analysing the impacts of subsidies granted by a LAG located in a northern sparsely populated area. This was done via a case study of LAG funding, utilizing the perspective of beneficiaries, gathered through 25 entrepreneur interviews.

Interviews were conducted using the same research process and the same semi-structured questionnaires. The data and the case study evidence were further analysed and synthesized.

In Finland, support, financing instruments and systems are mainly designed for larger sized companies and their business needs rather than for microenterprises. Therefore, this study, focused on Leader subsidies to microenterprises, is exceptional and interesting.

PUBLIC BUSINESS SUBSIDIES

Public subsidies for enterprises consist of funding or grants paid from public funds to a company or organization. The criteria for granting public subsidies for enterprises are based on law. According to Statistics Finland (2013), in 2011, 500 million euros in direct public subsidies were granted. The major forms of support were paid by the Ministry of Employment and the Economy, the Ministry of Agriculture and Forestry, and TEKES (the Finnish Funding Agency for Technology and Innovation). About 35 000 companies received support, which is about 11% of all enterprises. In addition to direct subsidies, the public sector supports enterprises in the form of loans, equity loans and guarantees. By industry, the most direct beneficiaries were the service sector enterprises (Official Statistic of Finland, 2013).

In addition to national funding, public funding is channelled to businesses at the regional level. The number of actors in business services and funding is huge. National funding is supplemented by the European Structural Fund that targets regional policy funding. In addition to EU funding, 290 million euros are allocated annually by government and municipalities in EU projects. The majority of those structural fund programs are aimed, in one way or another, at the areas of economic and business competitiveness (Puttonen and Kähönen, 2010).

A major number of Finnish companies are micro-, small- and medium-sized operators who primarily seek local funding. Their name recognition and relevant business information are local. Thus, despite global financial markets, the availability of local funding is important, because it promotes the growth and innovation of smaller firms (Rautio, 2009).

In 2013, the main reasons that microenterprises applied for public funding were using it for development projects, easiness of obtaining public funding, and the lack of bank and other private funding. In the past 12 months, about 12% of micro-sized companies have used public subsidies (Enterprise Finance Survey, 2013). Koski and Pajarinen (2010) found that the probability of applying for and receiving public support increases with size, age, research and developmental intensity of the enterprise.

According to Pietarinen (2012), almost half of public business subsidies turned out to be efficient and effective in relation to an objective and had the effect of changing the

economic structure. According to Koski and Pajarinen (2013) none of the subsidy types have significant impacts on the firms' productivity performance, either in the short term or the longer term.

Koski and Ylä-Anttila (2011) found that young companies seem to seek business support actively. However, business subsidy authorities seem to prefer the larger, more stabilized companies. The study also provided some evidence that many of the subsidies are granted by authorities who prefer the same "regular customers" from year to year. This is due to the fact that the applicants have learned to seek the support, and business subsidy authorities get to know the applicants; thus the companies that received support in the past may have an advantage over other firms. However, granting the subsidies repeatedly to the same companies is inconsistent with the aim that subsidies are intended to be temporary. Their function is to compensate for market failures, not to be a continual aid. Public funding should be selective and target only those companies that really need it (Hyytinen and Väänänen, 2002).

According to Pietarinen (2012), as with any business policy action, the effectiveness of business subsidies is difficult to evaluate. The impact on the development of the beneficiary enterprise is difficult to separate from other factors. It is even more difficult to evaluate wider externalities connected to support. According to Koski and Ylä-Anttila (2011), evaluating effectiveness is very challenging, because the development of the supported firm cannot be detected without the support, and alternative development cannot be detected, and because companies are heterogeneous and the allocation of subsidies is not random. In addition, the potential adverse effects of the support are very difficult to observe. A principle of evaluating the impact of public policies in assisting the small business sector is that its prerequisite is the specification of the objectives of the policy (Storey, 1998).

LOCAL ACTION GROUP AS A FUNDING ACTOR

LEADER is an abbreviation which comes from the French words, "Liaisons Entre Actions de Développement l'Économie Rurale". It is funded by the European Union Community Initiative Programme, which supports rural development. The Leader program is implemented by local action groups (LAGs). In Finland, LAGs are associations that develop rural areas by funding local rural development projects and supporting local enterprises. The Leader approach came to Finland with the EU membership of the mid-1990s.

Finland's Leader LAGs apply all of the same key principles followed in Leader work around the EU: the "bottom up" principle; the drafting of local development plans; direct and trusting collaboration and work-sharing between the public and private sectors; openness and transparency; and innovativeness and networking. Project preparation and decision-making on the projects funded is done by ordinary people, who are the best experts in their home areas. The LAGs' activities have a strong local focus. They strive to develop the countryside

through initiatives taken by local people. The target group of LAG business subsidies is small businesses which are just starting or are developing their business.

Local Action Group Keskipiste-Leader

Keskipiste-Leader is the LAG located in Northern Ostrobothnia. The Keskipiste-Leader's operation area is the subregions of Nivala-Haapajärvi and Haapavesi-Siikalatva. The subregions consist of the municipalities of Haapajärvi, Haapavesi, Kärsämäki, Nivala, Pyhäntä, Pyhäjärvi, Reisjärvi and Siikalatva. This region can be described as entrepreneurial, with strong, basic agriculture, wood-growing, metal and tourism industries. In addition, the area has a youth-oriented demographic structure.

This area is Finland's leading area of milk and meat production. Alongside agriculture, forestry has a significant impact on employment. Industry, services and the primary sector offer a total of about 70% of workplaces in the area. Growing industrial sectors have been the metal industry and the wood products industry. Metal structures and machinery and equipment manufacturing, as well the electronics and mechanics of the electronics industry, have increased their labour forces in recent years. The operating area of Keskipiste-Leader includes 775 companies in the subregion of Haapavesi-Siikalatva and 1555 companies in the subregion of Nivala-Haapajärvi.

Table 1. The number of companies in Keskipiste-Leader's area of operation (Jokela et al. 2014).

Subregion	Companies
Nivala-Haapajärvi	1555
Haapavesi-Siikalatva	775
Total	2330

Table 2 shows staff categories of companies by subregion. Of the companies in the subregions, 95.4% (2224 units) are micro-sized, with fewer than 10 employees. Companies that employ 50 or more people are 17 (0.7% of the companies). In the operation area of the LAG, the number of large companies which have more than 250 employees is very low, with only one in the subregion of Nivala-Haapajärvi.

Table 2. Personnel categories of companies by subregion (number of companies*) (Jokela et al. 2014).

	Number of personnel in company						
	0–9	*10–19*	*20–49*	*50–99*	*100–249*	*250–499*	*Total**
Nivala-Haapajärvi	1490	38	17	7	2	1	1555
Haapavesi-Siikalatva	734	24	10	5	2		775
Total	2224	62	27	12	4	1	2330

Table 3 shows the turnover of companies, in millions of euros, by subregion. There are 1762 (75.6%) companies which have less than a 0.2 million euro turnover, while the number of companies which have a million euro or more turnover is 145 (6.2% of the companies).

Table 3. Turnover of companies by subregions (number of companies*) (Jokela et al. 2014).

	Turnover of companies - million euros							
	Under 0,2	*0,2– 0,39*	*0,4– 0,99*	*1– 1,99*	*2– 9,99*	*10– 19,99*	*Over 20*	*Total**
Nivala-Haapajärvi	1187	140	136	45	36	4	7	1555
Haapavesi-Siikalatva	575	82	65	27	17	3	6	775
Total	1762	222	201	72	53	7	13	2330

Enterprise subsidies of Keskipiste-Leader

Keskipiste-Leader is a LAG which operates in two subregions in Northern Finland. The object of this effectiveness monitoring study is to analyse the subsidies granted by Keskipiste-Leader between 2005 and 2009. This period covers two different EU development programmes for the periods 2000–2006 and 2007–2013.

The Leader's principles for granting subsidies were that the projects had to have economic objectives; they should try to directly or indirectly create workplaces or businesses. The LAG can grant funds to micro-sized companies, which employ fewer than 10 people. The main focus of the Leader business subsidies is to support start-ups and the expansion of small businesses. Subsidies could, however, be granted on a flexible, case by case basis to businesses employing fewer than 10 people. In supporting small businesses, the LAG did not set strict limitations on different business sectors. The subsidies have been designated specifically for start-ups and small businesses in rural areas, based on the region's needs within the framework of the law. Subsidy applicants must be 18–62 year old natural person or company controlled or owned by such person. Applicants must have adequate education in their area of business or have at least three years of work experience or three years of education along with employment experience.

Subsidized businesses should be full-time, but LAGs can also support part-time businesses. And most importantly, subsidized businesses should be located in the LAG's

geographical area of operation. A LAG particularly supports starting and expanding micro-sized companies. The LAG's subsidies are divided into three groups: investment in the business (35%), development of the business (50% / 90%) and start-up of a business (50%). The percentages indicate the subsidies' maximum percentage of the total cost of the project.

METHOD

This study is a holistic, multi-case study (see Yin, 1989). The aim of this case study is to deepen and discover a cause and effect relationship within a phenomenon. According to Yin (1989), a case study is an empirical research strategy that examines a modern-day phenomenon in its real context, when the interface between the phenomenon and the context is not clear. Evidence is used from multiple sources. The case study is used to retrieve answers to questions, in particular, "Why?" "What?" and "How?" A case study is at its best when the approach is to investigate in depth cause and effect relationships or long-term chains of events (Saunders 2012). A case study is also suitable for exploratory and descriptive research. The case study can be used to examine one case or several cases (see Saunders, 2012).

The interviews for this effectiveness monitoring study of LAG subsidies were conducted with 25 beneficiary companies that had received LAG subsidies granted during 2005–2009. In that period, the beneficiary companies numbered 97, but the number of LAG subsidies was higher. This is due to the fact that some of the beneficiary enterprises had received a subsidy more than once. Data was gathered during the autumn of 2013, through face-to-face interviews using structured questionnaires. For the purposes of the study, the time interval was selected so that at the time of the interview, enough time had passed since the subsidies were granted that long-term monitoring by the entrepreneurs was possible.

RESULTS

Ten of the case companies were located in the Haapavesi-Siikalatva subregion and 15 in the Nivala-Haapajärvi subregion. In 2012, the case companies employed an average of four people, 22 were micro-sized companies (employing fewer than 10 people), and three companies had grown to more than 10 employees. In addition, the mean turnover of the case companies was 350 000 euros. The criteria for the subsidies were, in four cases, development projects and in 21 cases, investment or the establishment of business. The average amount of subsidy per company was 11 518.62 euros, and average support level of 38.4%. At the time of the interviews, five of the case companies were on a clear growth path, while in four cases, the businesses had ended. The main reasons why the businesses had been forced to close down were the health of the entrepreneurs and/or the unprofitability of the businesses. It should be noted that in the fourth column in Table 4, the number of employees of the case companies is the situation in 2012, rather than the situation at the time the subsidy was granted.

Table 4. Basic information about case companies

Company	Subregion	Number of staff in 2012	Turnover in 2012 €	Criterion of subsidy	The current performance (not operating, decreasing, stable, growth)
1	H-S	1	10 000	investment	stable
2	H-S	1	10 000	investment	decreasing
3	N-H	1	3 000	investment	stable
4	H-S	1	8 000	development	not operating
5	N-H	2	200 000	development	growth
6	N-H	17	2 700 000	investment	growth
7	N-H	6	750 000	investment	stable
8	H-S	0	0	investment	not operating
9	N-H	1	3 000	investment	stable
10	N-H	17	1 400 000	investment	growth
11	N-H	1	9000	investment	decreasing
12	H-S	1	60 000	investment	stable
13	H-S	7	932 000	investment	stable
14	N-H	6	700 000	investment	decreasing
15	N-H	13	1 700 000	investment	growth
16	N-H	0,5	20 000	investment	stable
17	N-H	1	85 000	investment	stable
18	N-H	1	75 000	investment	stable
19	H-S	0	0	development	not operating
20	H-S	1	55 000	investment	stable
21	H-S	4	150 000	investment	growth
22	N-H	5	230 000	development	decreasing
23	N-H	6	300 000	investment	stable
24	N-H	4	540 000	investment	not operating
25	H-S	3	500 000	investment	stable

Based on these results, significant differences concerning the locations of the companies cannot be identified between the subregions. This is due to the heterogeneity of the beneficiary companies. The case companies represented part-time or full-time businesses, companies in different business sectors, companies in various growth phases and companies with varying levels of desire to grow. In addition, the amounts of subsidies and targets vary from case to case; the granted subsidies ranged from 1 000 euros to about 50 000 euros.

A limitation regarding the reliability of the results is that some planned interviews did not take place, since the business owners refused to be interviewed, mostly citing the rush of business as well as the cessation of business. It is possible that an entrepreneur is more likely to agree to participate in an interview when their experiences with LAG subsidies are positive and when their own business has been successful.

Based on the interviews, entrepreneurs felt that the objectives, which were settled beforehand for their projects, were well achieved. The direct objective of a subsidized project, for example, a business start-up or a new machine, was nearly always achieved well. According to the entrepreneurs, the broader, more indirect effects of the subsidized project were also positive in the short term. These effects included the following: increasing the quality of the product or service; skills improvement; faster production; conservation and improvement of competitiveness; improvement of the company's image and credibility; the possibility of self-employment; a business start-up; new products and services; and new customers and service volumes. Entrepreneurs considered that the provided business subsidies were proper alignment and necessary to their business operations in the short term. However, in some cases, even in the short term, the expected indirect impacts to business were not obtained, even though the project itself was considered a success.

In the interviews, the entrepreneurs were asked about whether the investment or the development project would have been implemented without the funding granted by the LAG. This phenomenon is called the deadweight effect. On the grounds of the responses, there was considerable variability in the subsidies' deadweight between the cases. Few entrepreneurs felt that the support was determinative of the whole investment or development project; however, the majority of the interviewed entrepreneurs would have carried out their projects even without public funding, albeit often on a smaller scale, later, or in stages.

Concerning the influence and firm-level impacts of the LAG subsidy, the entrepreneurs mostly highlighted the encouraging and supportive effects. Often, the support dispelled uncertainty, and thus, for example, lowered the threshold for starting a new business. Without public funding, the enterprise might have had to rely on a higher bank loan or might have needed to distribute investment or development measures over a longer term. Receiving the support of a subsidy for a business start-up was not necessarily a determining factor in the decision, but it created support and brought security for starting a new career as entrepreneur. In one case, the actual supported project did not create the new and stable business as expected, but it had an indirect, positive developmental effect on the entrepreneur's other business. In addition, in all cases, the subsidized project did not lead the objective volume of business, but still created a seasonal business.

The interviewees described the importance of the subsidy received by saying that, for example, it made possible the acquisition of better or more versatile equipment than would have been possible without the support. This increased and accelerated growth, improved competitiveness, created efficiency and effectiveness, and enabled the adoption of new technologies.

In the most successful cases, the LAG's business subsidy occurred in the right place at the right time. That made possible the rapid growth of the enterprise via successful investment and contributed to the hiring of additional labour. Funding support also enabled

the deployment of modern technology, which meant that the company was able to remain competitive in the market. In addition, subsidized investment was also a precondition for the new creation of a strategic partnership. Via the new partnership, the entrepreneur managed to reach new markets and was able to increase business volume.

In addition to the importance of financial support, significance was also given to the application process, which can provide the entrepreneur with more information and provide an understanding of the planned investment or business. For example, the LAG required a business plan before the establishment of the business, which clarified the overall picture and provided a hope of success to the business. Very many interviewees highlighted the fact that the subsidy also provided mental encouragement to them.

In some cases, the supported investment was necessary and could have been successful and could have met its predetermined objectives, but changes in the business environment and tougher competition may have led to business contraction, recession or exhaustion. For example, some changes in circumstance that were mentioned were deterioration in health, changes in one's personal life situation or the withdrawal of important business partners. Also, changes in the industry sector and the negative prospects that resulted may have led to an undesirable development. Naturally, the general economic downturn also produced challenges for beneficiary enterprises.

In monitoring the effectiveness of subsidies, company-specific growth targets must be considered. A subsidized project can be successful from the entrepreneur's perspective, even if it has not led to the growth of the company; it may have provided the opportunity to become self-employed, even if in some cases, it was only part-time. Even if the business did not always reach the desired outcome, such as providing a full-time livelihood, the subsidized investment or development project may have contributed to other business areas. The interviewees expressed the view that the supported project also contributed indirectly to other softer values such as the survival of local cultural history. In addition, to some extent, the LAG's local funding to microenterprises helped to create a new kind of business in the region, which may be considered a positive, in assessing the effectiveness of business subsidies.

At the time of the interviews, five of the subsidized enterprises were clearly on a growth path. Three enterprises had received business subsidies for start-up investment, one for expansion investment and one for a development project. On the grounds of the interviews, three of these companies feel that the investment project subsidized by LAG played a key role in the positive development of the company.

In the long term, support granted to a microenterprise may not necessarily always be a major influence on the company's situation or on the overall volume, but according to the entrepreneurs, the impacts can still be relevant to the credibility, accuracy and quality of the

production. Even if a business subsidy is not financially major, its meaning can be crucial when it is allocated at the right time and in the right place.

The information about the availability of the LAG subsidies had reached companies in a many cases through colleagues and friends, that is, through the grapevine, or through other public business services such as local public business advisory services. Other information channels mentioned were information acquisition about funding opportunities on their own as well as the LAG's marketing and participation in various events in the area. Some of entrepreneurs asked for and gained assistance from local public advisory services in applying for the subsidy. In particular, the experience of entrepreneurs who were starting businesses was that support from public business advisory services offered superior value during the application process.

DISCUSSION

According to the results, one of the main ways to obtain information about subsidies granted by the LAG was through local public business advisory services. It seems that the local advisory services' central role as an intermediary organization works effectively in the case area. One characteristic of sparsely populated and rural areas is that the level of private funding in the market is reduced compared to that in the large centres. For this reason, intermediary organizations have emphasized role between public funding and enterprises in the sparsely populated areas. It is therefore particularly important that the mutual exchange of information between the LAG and the local business advisory services about funding opportunities is regular and up to date. From the LAG's perspective, public business advisory organizations should be seen as some of the central stakeholders and as marketers for the LAG's funding opportunities.

Based on the interviews, the main impact of the LAGs' business subsidies on the beneficiaries has been to play an encouraging, supportive and complementary role. Often, the support has removed uncertainty and lowered the threshold for starting a business. These considerations were highlighted by the entrepreneurs as the most important effects in both the short and the long term. A number of entrepreneurs, while going through the application process and receiving the actual funding, also experienced a boost in mental confidence and trust in their planned operations. In particular, receiving public support for the establishment of their business gave confirmation that the business idea might really work. Although the amount of funds granted to the enterprises was relatively small in terms of euros, the subsidies have had successful impacts on the attitudes of the entrepreneurs. Therefore, the overall effect of the support is often greater than the mere granted amount of money.

The overall business situation of the participating enterprises was stable in half of the enterprises, at the time of the interviews, compared to the situation prior to the subsidy. Five of the interviewed enterprises were clearly on a growth path at time of the interview. In three

of these cases, it can also be clearly said that in the long run, the subsidies granted by the LAG have contributed a positive impact on the enterprise's growth and employment. In addition, an entrepreneur already in a stable situation has often managed employment for many years with the contribution of the subsidy.

REFERENCES

1. Aaltonen, S., Akola, E., Heinonen, J., Laalo, H., and Nummelin, L. (2013), "Yritystukilain vaikuttavuuden ja toimivuuden arviointi", Publications of the Ministry of Employment and the Economy, Employment and Entrepreneurship 23/2013.

2. Enterprise Finance Survey (2012). "Yritysrahoituskysely", Published by Confederation of Finnish Industries (EK), The Federation of Finnish Financial Services, Finnvera, Bank of Finland, Federation of Finnish Enterprises, Ministry of Employment and the Economy, available at:
http://www.suomenpankki.fi/fi/julkaisut/selvitykset_ja_raportit/rahoituskyselyt/Docume
nts/YRK_2012/index.html (accessed 11 April 2014).

3. Enterprise Finance Survey (2013), "Yritysrahoituskysely", Published by Confederation of Finnish Industries (EK), The Federation of Finnish Financial Services, Finnvera, Bank of Finland, Federation of Finnish Enterprises, Ministry of Employment and the Economy, available at:
http://www.suomenpankki.fi/fi/julkaisut/selvitykset_ja_raportit/rahoituskyselyt/Docume
nts/YRK_2013/YRK_2013_A4.pdf (accessed 11 April 2014).

4. European Commission (2013), "Innovation union scoreboard, available at:
http://ec.europa.eu/enterprise/policies/innovation/files/ius-2013_en.pdf (accessed 11 April 2014).

5. Hyytinen, A., and Väänänen, L. (2002), "Government funding of small and medium-sized enterprises in Finland", ETLA Discussion paper [832], The Research Institute of the Finnish Economy.

6. Jokela, H, Niinikoski, E-R., and Muhos, M. (2014), "Characteristics of enterprises in Oulu South region" (In Finnish: Oulun Eteläisen alueen yrityskuva), Working paper [in DIEM 1/2014], University of Oulu.

7. Koski, H., and Pajarinen, M. (2010), "Supply, complementarities, and repetitiousness of public support in Finland", Keskusteluaiheita, ETLA discussion paper [1217], The Research Institute of the Finnish Economy, Helsinki.

8. Koski, H., and Pajarinen, M. (2013a), "The role of business subsidies in job creation of start-ups, gazelles and incumbents", *Small Business Economics*, Vol. 41 No. 1, pp. 195–214.

9. Koski, H., and Pajarinen, M. (2013b), "Subsidies, shadow of death and productivity", ETLA working paper [16]. Available at: http://pub.etla.fi/ETLA-Working-Papers-16.pdf

10. Koski, H., and Ylä-Anttila P. (2011), Yritystukien vaikuttavuus: tutkimushankkeen yhteenveto ja johtopäätökset. (The effectiveness of support to enterprises: summary and conclusions). Finland's Ministry of Employment and the Economy, reports 7/2011.

11. Lundmark, L. (2006), "Restructuring and Employment Change in Sparsely Populated Areas: Examples from Northern Sweden and Finland", Akademisk avhandling Kulturgeografiska institutionen Umeå universitet, GERUM 2006:2.
12. Official Statistic of Finland (2013), "Yritystukitilasto 2011", available at: http://www.stat.fi/til/yrtt/2011/yrtt_2011_2013-04-03_fi.pdf (accessed 11 April 2014).
13. Ponnikas, J., Voutilainen,O., Korhonen, S., and Kuhmonen, H-M. Maaseutukatsaus (2014), Publications of the Ministry of Employment and the Economy 2/2014.
14. Puttonen, V. and Kähönen, H. (2010), Julkisen kasvurahoituksen ja yritystukijärjestelmän kehittäminen. Selvitysmiehen raportti. Publications of the Ministry of Employment and the Economy, Innovations 29/2010, Edita Publishing Oy.
15. Rautio, E. (2009), "Enhancing the operating conditions and financial resources of emerging growth companies" (In Finnish: "Kasvuyritysten toimintaedellytysten parantaminen ja rahoituksen tehostaminen"), Ministry of Finance publications 8/2009.
16. Saunders, M., Lewis, P., and Thornhill, A. (2012), *Research methods for business students*, Pearson, Essex.
17. Storey, D. (1998), "Six steps to heaven: Evaluating the impact of public policies to support small business in developed economics", Working paper [59/1998], Warwick Business School.
18. Yin, R. (1989), *Case Study Research: Design and Methods,* Sage Publishers, Beverly Hills.

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CHOOSING THE RIGHT INTEGRATION STRATEGY FOR INNOVATION

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ABSTRACT

Mergers and acquisitions are an important tool for companies to achieve fast, external growth by e.g. acquiring new knowledge to face competition. The importance of the topic is indicated by the tremendous M&A volume, which has been reached in the last few years and is comparable to the GDP of large countries.

In this paper we focus on the role of innovation in transactions. More specifically, within an empirical study of 101 transactions in the German-speaking part of Europe, we examine whether integration on the human and task level during the post-merger phase reveals differences regarding the merged firms' overall ability to innovate. Our study contributes to existing research, as we find empirical support that the amount of changes regarding both human and task integration have a different impact on innovation characteristics in M&A.

The distinction between task and human integration provides a clearer understanding of means for coordination mechanisms. Hereby, task integration involves the identification and realization of operational synergies through capability transfer, resource sharing and learning. In contrast, human integration seeks to establish a shared identity and atmosphere of trust among employees of both sides. Innovation was analyzed regarding three different characteristics – upstream performance, new product development, and product enlargement.

Our findings reveal that the ability of exploration is dependent upon different levels of completion or emphases along both axes of integration. We find significantly diverse results in all three innovation characteristics: Regarding upstream performance, high human and high task integration results in the greatest possible degree of innovation, whereas human integration appears to be more beneficial than task integration. In terms of new product development, we find that again the highest degree on both axes shows that most innovative capabilities. However, hereby integration of tasks appears to be more beneficial than human integration. Regarding product enlargement, our results show that high task and low human integration is

the best approach leading to innovation. Hereby, operational synergies appear to have a more positive impact, as diversification of products rather requires resource sharing and capability transfer than a common culture in order to exploit synergies.

		Upstream Performance		New product development		Product enlargement	
Human integration	high	++	+++	+	+++	++	++
	low	0	+	0	++	0	+++
		low	high	low	high	low	high
		Task integration					

Keywords: Mergers and Acquisitions, integration process, human integration, task integration, innovation

INTRODUCTION

From a strategic perspective, mergers and acquisition (M&A) are not only useful to overcome external challenges such as negative market developments, state reforms or technological changes (Child, Faulkner, & Pikethly, 2001), but also to speed up corporate growth for higher performance (Hitt, Harrison, Ireland, & Best, 1998; Hoskisson & Hitt, 1990; Krishnan & Park, 2002), or to expand a company's competences (Schoenberg, 2003). Therefore, it is no surprise that M&A volumes exhibit an increasing tendency, which is shown by the rise of the aggregated volume of worldwide transactions from $2.23 to $2.33 trillion between 2012 and 2013 (Bloomberg, 2014). In light of these considerable sums, failure rates of 40-60% (Cartwright & Cooper, 1993) and even up to 70-90% (Christensen, Alton, Rising, & Waldeck, 2011) call for a deeper understanding on strategic steering mechanisms in order to realize intended synergies. Particularly with regards to innovative capabilities acquisitions appear to be promising for the innovation output of the acquirer when absorbing the target firm's knowledge base (Ahuja & Katila, 2001). With the purpose of integrating external innovation in mind the acquirer intends to remain competitive (Hitt, Hoskisson, Johnson, & Moesel, 1996). However, researchers also revealed that the innovation performance declines after a transaction (Hitt, Hoskisson, Ireland, & Harrison, 1991), among others due to disruption of inventors (Paruchuri, Nerkar, & Hambrick,

2006), transaction costs or an overemphasis on financial controls (Hitt et al., 1996). Thereby the post-merger integration, when the involved parties are brought together in order to realize synergies (Gates & Very, 2003), constitutes the key issue for value destruction (Teerikangas & Joseph, 2012; Zollo & Singh, 2004). By drawing on the concept of exploration and post-merger integration we provide empirical evidence that a differentiated view on dimensions of integration and innovation outcomes should be considered when acquiring innovation capabilities.

THEORY AND HYPOTHESES

Post-merger integration and innovation

Many cross-border transactions are conducted to obtain access to new markets, hence recently an increasing importance of acquiring new technologies and know-how could be observed (Bertrand & Zuniga, 2006; Cassiman, Colombo, Garrone, & Veugelers, 2005; Grimpe & Hussinger, 2013; Makri, Hitt, & Lane, 2010). Thereby companies can improve their innovative performance by buying innovative targets (Ahuja & Katila, 2001; Björkman, Stahl, & Vaara, 2007; Vermeulen & Barkema, 2001), whereas a certain degree of relatedness in their knowledge base fosters innovativeness (de Man & Duysters, 2005). Particularly technological companies operating globally use M&A to increase their accumulated know-how (Birkinshaw, Bresman, & Nobel, 2010) and to consequently improve their innovation output (Ahuja & Katila, 2001; Cloodt, Hagedoorn, & Van Kranenburg, 2006). Alternatively, creating innovation organically is slower and more challenging to achieve (Prabhu, Chandy, & Ellis, 2005). Even though M&A are a key to extending companies knowledge bases (Chakrabarti, Hauschildt, & Süverkrüp, 1994; Gerpott, 1995) the relationship between M&A and innovation has been underrepresented in literature so far (Cassiman et al., 2005).

In general, a closed M&A transaction is just a legal perspective of bringing two companies together, but does not mean at all that both involved parties operate as a united entity (Schweizer, 2005). According to Shrivastava (1986) as well as Teerikangas and Joseph (2012) integrating two merged organizations into one unit constitutes the key problem in effectively managing M&A. Disregarding the context – whether integration related to M&A or to the unification of two units within a single company – organizational integration generally refers to "the extent to which distinct and interdependent organizational components constitute a unified whole" (Barki & Pinsonneault, 2005, p. 166) and demands that both sides learn to work together and learn to cooperate in the transfer of strategic capabilities during an interactive and gradual process (Quah & Young, 2005).

Taking a closer look at innovation, achievements from interdependent units collaborating with each other are ubiquitous (Kretschmer & Puranam, 2008). However, the value of integrating an acquired firm into the buyer might seem promising during the pre-acquisition screening and due

diligence process, but still remains unrealized potential until the day of actual integration (Ranft & Lord, 2002). Therefore, the effective use of existing capabilities plays the most important role in the post-acquisition integration of operations (Datta, 1991) and needs to be handled carefully in order to realize any synergies (Chatterjee, Lubatkin, Schweiger, & Weber, 1992).

Until now, the observed relationships between M&A and innovation show a very heterogeneous picture (Ahuja & Katila, 2001; Ernst & Vitt, 2000) whereas these study results are hard to transfer into a bigger framework (Cassiman et al., 2005; Cassiman & Ueda, 2006; Hitt et al., 1991; Paruchuri et al., 2006). Usually innovation gets boosted by exchanging and sharing knowledge bases between buyer and target (Birkinshaw et al., 2010) and an interaction of both complementing knowledge stocks fosters innovation success (King, Covin, & Hegarty, 2003). Though, some findings show a different picture when knowledge bases get disrupted in the post-merger integration. An integration of knowledge bases following M&A activity is often accompanied by a decreased innovation output resulting in a lower number of patent applications (Paruchuri et al., 2006). Nevertheless, these negative effects can be weakened through purposely integrating to a very small degree only. Puranam, Singh and Chaudhuri (2009) showed that integration of knowledge bases does not lead to a higher innovation output and is unnecessary. The post-merger integration phase may be the reason for these differing results, as different acquisition strategies (e.g. market access and knowledge) necessarily need to be followed by different integration approaches according to the intended strategy outcomes.

Since Shrivastava (1986), research considers M&A integration as a highly complex multifaceted process. Taking the importance of the post-merger integration into consideration, the challenging question acquirers have to ask is how to choose the right integration strategy in order to preserve capabilities of technology-based target companies (Puranam, Singh, & Zollo, 2006). However, integrating R&D operations is one of the most challenging tasks due to the tacitness of knowledge (Birkinshaw, Bresman, & Håkanson, 2000) and can disrupt inventors so much, that no synergy effects can be realized (Paruchuri et al., 2006; Puranam et al., 2009).

In order to untangle the rather complex sequences within the post-merger integration process, a differentiation has to be made by considering cultural and task integration as separate entities within the integration process. On the one hand, cultural integration thereby facilitates creating a shared identity and mutual thrust amongst employees, which is essential for satisfied staff (Birkinshaw et al., 2000). On the other hand task integration is understood as base for transferring resources and eliminating redundant capabilities (Angwin, 2004). However, strategies for realization of innovative capabilities may vary in terms of different dimensions of exploration and exploitation orientation of target companies (Birkinshaw & Gupta, 2013).

There are researchers who report that integrating tasks results in disruptions keeping firms to create synergies: According to Benner and Tushman (2003) process management activities, in general, create impacts which provoke resistance to change and, consequently, inhibit the organization's variability and ability of adaptation. Task integration in the context of a merger or acquisition also includes managing processes and therefore causes disruptions due to substantive incompatibilities as a result of shock caused by living in a different organizational world (Buono, Bowditch, & Lewis, 1985). This has been observed in particular when firms have been acquired due to their innovative capabilities and when the success of an acquisition was dependent upon the acquirer's ability to retain inventors and maintain their productivity (Hitt et al., 1991).

We consider innovation capability from different perspectives: Assuming that the involved companies have a certain level of absorptive capacity, integrating new knowledge or technology (Cohen & Levinthal, 1990) can be deliberately utilized to introduce new products or to enlarge the product range (He & Wong, 2004). Despite this, a successful integration strategy can result in unexpected product or process innovations and thus, can be considered as a by-product of intensive collaboration with regards to technology and know-how exchange between the merged firms (Nielsen & Gudergan, 2012).

Human integration

Effects on the human dimension are of particular importance during the post-merger phase (Quah & Young, 2005) when organizations are integrated in order to create satisfaction and a shared identity among organizational members of both companies (Birkinshaw et al., 2000). Creating a common mindset is a way to manage cultural differences no matter whether there exist organizational and / or national cultural differences (Schweiger & Goulet, 2005). The need for a common or shared identity between the acquiring and target firm stems from the negative consequences of cultural differences: According to Cartwright (2012) many M&A fail as a consequence of managers' underestimation of certain difficulties when integrating acquired personnel and the potential for cultural clash. The term 'cultural clash' captures emotions and conflicts, which occur due to cultural differences (Very, Lubatkin, Calori, & Veiga, 1997) and result in high levels of stress (Sarkar, Echambadi, Cavusgil, & Aulakh, 2001), insecurity, hostility against the acquiring firm (Paruchuri et al., 2006), and increasing fluctuation. Acculturative conflicts caused by cultural disruption can negatively impact the entire course of integration (Reus & Lamont, 2009; Slangen, 2006; Weber, Tarba, & Bachar, 2011), irrespective of whether the cultural difference is on an organizational or national level (Björkman et al., 2007; Teerikangas & Very, 2006). A cultural clash is strongest where the encounter between both parties is most intensive (e.g., determination of goals, strategic choices, etc.) which is proven to result in lower top management commitment and lower cooperation between both organizations (Weber, Shenkar, & Raveh, 1996) and consequently leads to difficulties in achieving operational synergies, to market share shrinkages, and to poor performance (Datta,

1991). Thus, being successful in creating an effective common set of beliefs, attitudes, and trust is vital for a smooth relationship and fruitful collaboration. Thereby, human integration mechanisms positively impact the acquisition success (Larsson & Lubatkin, 2001; Martinez & Jarillo, 1991) since employees can develop shared understandings, constructive perceptions and attitudes of each other (Schweiger & Goulet, 2005). The main drivers of human integration stem from the concept of social capital where the central proposition claims that networks of relationships constitute a valuable resource. This is necessary in order to increase efficiency of actions as well as information diffusion, or in order to reduce transaction costs, and facilitate new forms of association and innovation (Nahapiet & Ghoshal, 1998). During the cooperative process of acculturation beliefs, assumptions, and values of the previously independent workforces are supposed to form a jointly determined culture (Larsson & Lubatkin, 2001), a unified organizational frame. Since developing innovative capabilities requires loosely coupled systems, organic structure, autonomy and chaos in order to foster path-breaking activities or technologies (He & Wong, 2004), a common set of values and a shared identity are supposed to set the required framework for new product development. As a consequence we hypothesize:

Hypothesis 1 (H1): A high level of human integration leads to a higher level of innovative capabilities with regards to new product development.

The basic logic is that greater cultural understanding, resolution of cultural differences, communication, commitment and cooperation between both integrated firms can be built by deep-level cultural learning interventions, such as intergroup mirroring exercises, common leisure activities, work-unit meetings, or weekly follow-ups (Schweiger & Goulet, 2005). This approach might also be applicable to the human integration of firms which have been acquired for their technological or innovative capabilities, as Sarala and Vaara (2010) proved that cultural convergence (reducing organizational differences) and cultural crossvergence (developing a new culture with a common belief and value system) have a positive impact on knowledge transfer. The result is closer inter-unit relationships and increased trust, which enhances capability transfer between both firms (Björkman et al., 2007). Consequently, when members of an organization trust each other and when cultural distances are low, efficiency increases (Nielsen & Gudergan, 2012) because employees more consistently act in the interest of the merged firm (Riketta, 2005; van Dick, Ullrich, & Tissington, 2006). Therefore we derive the following hypothesis:

Hypothesis 2 (H2): A high level of human integration leads to a higher level of innovative capabilities regarding product enlargement.

Task integration

The concept of integrating tasks during the post-merger phase involves sharing resources, transferring and learning capabilities with value creation as the overall objective of the acquisition (Birkinshaw et al., 2000; Stahl & Voigt, 2008). Task integration leads to common goals, common procedures, and common authority (Puranam et al., 2009) with the greatest level of synergy realization when the degree of interaction and coordination is highest (Larsson & Finkelstein, 1999). Effects of combining tasks are not limited to the sole consolidation or coordination of functions and operations but also entail a mutual learning which results in the convergence between organizational and individual beliefs (March, 1991). Despite this, the exploitation of a firm's technological developments and capability to create innovations can also be facilitated by task integration (Puranam et al., 2006). Different approaches are suggested in order to balance the required degree of integration while minimizing disruptions to the target's resources and capabilities (Zollo & Singh, 2004) – ranging from integrating when the technology unit is not in the most exploration-intensive phase in the sequence of innovation (Puranam et al., 2006) to taking the interaction of inventor characteristics and integration into consideration (Paruchuri et al., 2006).

In order to increase success in terms of realizing synergies by sharing resources across organizations (Larsson & Finkelstein, 1999) operations should be combined and eliminated (Birkinshaw et al., 2000) to enable a more effective use of existing capabilities (Datta, 1991). Value creation can even be triggered, as high levels of integration in certain functions (e.g. distribution, logistics) can cause spillover effects on other functions (Häkkinen, Norrman, Hilmola, & Ojala, 2004). This process perspective on integration establishes stable patterns of communication and interaction by mapping processes, by improving procedures, and by adhering to systems of improved processes, and hence channels individual and group behavior into streamlined activities (Benner & Tushman, 2003). By integrating tasks, conditions are created which enhance the coordinated exploitation of common resources (Puranam et al., 2006). Standardized works and learned techniques generate knowledge which makes performance more reliable and reduces variability in the time to accomplish a task and also in terms of quality of task performance (March, 1991). The primarily efficiency gains result in innovative capability with regards to product extension, which leads us to the following hypothesis:

Hypothesis 3 (H3): A high level of task integration leads to a high degree of innovation capability regarding product enlargement.

According to Puranam and colleagues in case of significant levels of interdependence between the combined firm, integrating tasks is a powerful means to achieve coordination (Puranam, 2009). However, integrating operations and structures is bound by the merger objective (Datta, 1991) and how value is created is determined by the interdependence between acquirer and target

(Haspeslagh & Jemison, 1991; King, Slotegraaf, & Kesner, 2008). The degree of interdependence between acquirer and target does not only impact procedural and structural reconfiguration, but also information and knowledge transfer (Karim, 2006), which ideally increases the learning capabilities of both organizations. According to Vermeulen and Barkema (2001) acquisitions enrich knowledge bases, not only through direct knowledge transfer, when one organization learns from the experience of the other (Darr & Kurtzberg, 2000), but also implicitly, when the development of new knowledge is boosted by the infusion of new practices and knowledge, even if capabilities cannot be directly assimilated into the acquiring firm (Stahl & Voigt, 2008). So, knowledge sharing elevates a self-reinforcing cycle of competence (Zhou & Li, 2012). Refining and creating acquisition-specific tools can induce more learning outcomes through the creative process itself than the use of the outputs of coordination and implementation devices (Zollo & Singh, 2004). We assume that this knowledge and capability revitalization enhances business intelligence as well as idea management and therefore, we hypothesize:

Hypothesis 4 (H4): A high level of task integration leads to a high degree of innovation capability regarding new product development.

In order to take advantage of interaction and to implement mechanisms for both knowledge contribution and adoption, a context of understanding is required and the acquirer needs to have a profound comprehension of its own resources (Cording, Christman, & King, 2008; Darr & Kurtzberg, 2000). This perspective of organizational learning stems from ambidexterity theory, the balancing act between resource exploitation and exploration, which constitute the main element of system survival and prosperity (March, 1991). Knowledge sharing is considered a crucial means to accelerate product innovation (Kale & Singh, 2007), however, combining knowledge across organizations and functional units requires a lot of integration effort in terms of both culture and tasks. Apparently, in order to realize innovative capabilities both goals of creating a shared identity based upon trusts as well as a positive attitude towards each other (human integration) and the realization of operational synergies (task integration) have to be fulfilled. Based on this assumption, we derive:

Hypothesis 5 (H5): A high degree of both human and task integration results in the greatest possible degree of upstream performance.

METHODOLOGY

Data and sources

Survey methodology for data collection was applied in order to retrieve information on different integration levels and its outcomes. Questionnaires were sent to 1,247 managers from 616 companies from various industries with a response rate of 16.4% (a total of 101 useable

questionnaires), which can be considered satisfactory and in line with other studies in the area of M&A (Homburg & Bucerius, 2006). The majority of participating firms is from the German-speaking area of Europe (Austria, Germany, and Switzerland). Managers from the acquiring firms were approached, since they appear to be the most knowledgeable ones when it comes to the evaluation on post-merger integration (Homburg & Bucerius, 2005) and due to high turnover rates on the executive level in acquired firms (Walsh, 1988). Despite this, we only chose firms of the Zephir database by Bureau van Dijk which carried out transactions between January 01, 2007 and December 31, 2010 to guarantee that the integration phase has already been completed. We tested for a potential common method bias, since integration levels and outcomes were collected within one instrument, (Podsakoff, MacKenzie, & Podsakoff, 2012) by applying different instruments. In spite of reversing some of the questionnaire items in order to avoid response patterns, variables were separated in order to eliminate proximity effects (Podsakoff et al., 2012). Moreover, we conducted the Harman's Single Factor Test, which revealed that the model of this study is described by 15 different factors with the strongest factor explaining 38.78%. Therefore, it can be assumed that a common method bias does not pose a problem for our data.

Variables and measurement

Following King, Dalton, Daily, and Covin's (2004) advice established measurements, which are consistent with existing research, are borrowed from other related studies instead of developing them. This approach has been chosen in order to ensure that validity and reliability of indicators are given and to facilitate comparability with other studies. Appendix A provides an overview on item reliabilities and internal consistencies. Non-response bias was tested according to Armstrong and Overton (1977) – the examination of differences between late-respondents and early or normal respondents revealed no discrepancies. Hence, a late- or non-response bias can be excluded for the present study.

Human Integration

Human or cultural integration as one of the most covered topics in post-merger integration has been measured in various models. Yet, a precise differentiation of both constructs, cultural and task integration, only occurs in a few studies. Introduced by Birkinshaw et al. (2000) in a predominantly qualitative research design, the conceptualization has been referred to in many studies for theoretical terms. However, a quantitative application has been recognized in Cording et al.'s (2008) study as indicators for depth of integration so far. Therefore, Cording and colleagues' approach was borrowed to measure cultural integration.

Task Integration

Task integration is considered to be a coherent dimension within the integration process. Using a measurement that meets the interrelatedness of both human and task integration appears to be

vital in order to embrace both constructs equally. Consequently, indicators of Cording et al. (2008) are also applied for task integration.

Innovation capabilities

We considered innovation capabilities with regard to three dimensions in order to generate a differentiated view on innovation capabilities. Upstream performance is measured by using Nielsen and Gudergan's (2012) measurement, which involves two items. New product development and product enlargement were measured with single items.

RESULTS

The following table provides an overview on the descriptive data of our sample. Information on relative size, type of transaction, acquisition experience as well as location of target and acquirer is given.

Table 1: Sample descriptive data

Relative size	%	Type of transaction	%	Acquistion experience	%
< 25%	47.5	Horizontal	62.3	No experience	13
25% - 49%	37.7	Vertical	32.8	1-2	39
50% - 74%	9.8	Conglomerate	4.9	3-4	18
75% - 100%	0			5-6	8
> 100%	4.9			>7	16
				n/a	7

Location of Buyer & Targets	Acquirer			
Target	Germany	Austria	Suisse	Other
Germany	50%	8%	29%	33%

Austria	23%	62%	7%	22%
Suisse	9%	0%	21%	22%
Other	13%	31%	29%	22%

We used ANOVA to determine whether there are differences among the three innovation capabilities, for which significances were found. Our findings reveal that the ability of exploration is dependent upon different levels of completion or emphases along both axes of integration. We find significantly diverse results in all three innovation characteristics: Regarding upstream performance, high human and high task integration results in the greatest possible degree of innovation, whereas human integration appears to be more beneficial than task integration. In terms of new product development, we find that again the highest degree on both axes shows that most innovative capabilities. However, hereby integration of tasks appears to be more beneficial than human integration. Regarding product enlargement, our results show that high task and low human integration is the best approach leading to innovation. Hereby, operational synergies appear to have a more positive impact, as diversification of products rather requires resource sharing and capability transfer than a common culture in order to exploit synergies. Consequently, all hypotheses are confirmed.

Table 2: Illustration of results

		Upstream Performance		New product development		Product enlargement	
Cultural integration	high	++	+++	+	+++	++	++
	low	0	+	0	++	0	+++
		low	high	low	high	low	high
				Task integration			

DISCUSSION

Springboard of our research was the examination of different integration levels and their effects on innovation capabilities. Our study contributes to existing research, since we can provide evidence that an emphasis on changes of both human and task integration can foster innovation outcomes differently. So far several studies have analyzed effects of knowledge-transfer in the context of M&A from different points of view – for instance Paruchuri and colleagues (2006) examined productivity decreases of acquired R&D personnel caused by integration, Ahuja and Katila (2001) as well as Puranam et al. (2009) looked at integration and its influence on patenting outcomes, Cassiman and colleagues (2005) investigated on relatedness between acquirer and target and its impact on R&D performance, while Lakshman (2011) proposed a model on how cultural integration mechanisms lead to integration effectiveness and consequently pushes innovation benefits. Adding to previous research on the interface of M&A and innovation, we provide further understanding on integration strategies for innovation. More specifically, we conclude that integration along the two dimensions should be stressed differently depending on the intended outcome. Thereby, sought changes on the task dimension are mainly beneficial when it comes to product-related innovations, may it be the development of new ones or the enlargement of the extension of a product range. Resource transfer and knowledge sharing can be effectively exploited in order to develop new extensions (Grant, 1996; March, 1991) due to the leverage of existing capabilities. Here human integration does not lead to a better output because the collaboration gains are more important for process improvement and goal fulfillment. By contrast, the development of new products also requires some changes on the human level. We assume that this is due to the fact that a shared identity, which is developed through integration mechanisms on the human dimension fuels the absorptive capacity and thus leads to more innovative outcomes. When the merged entities should join forces inasmuch that innovative by-products that were not explicitly targeted, a strategic emphasis on human integration is needed. Reasoning is provided by the creative process of interaction itself, where learning outcomes are fostered (Zollo & Singh, 2004), which consequently lead to upstream performance. In summary, managers are well advised to consider our results in order to effectively integrate for in the context of their innovation intentions.

REFERENCES

1. Ahuja, G., & Katila, R. (2001). Technological acquisitions and the innovation performance of acquiring firms: A longitudinal study. *Strategic Management Journal*, *22*(August 1998), 197–220.
2. Angwin, D. (2004). Speed in M&A integration: The first 100 days. *European Management Journal*, *22*(4), 418–430. doi:10.1016/j.emj.2004.06.005

3. Armstrong, J. S., & Overton, T. S. (1977). Estimating nonresponse bias in mail surveys. *Journal of Marketing Research*, *14*(3), 396–402.

4. Barki, H., & Pinsonneault, A. (2005). A model of organizational integration, implementation effort, and performance. *Organization Science*, *16*(2), 165–179. doi:10.1287/orsc.1050.0118

5. Benner, M. J., & Tushman, M. L. (2003). Exploitation, exploration, and process management: The productivity dilemma revisited. *The Academy of Management Review*, *28*(2), 238–256.

6. Bertrand, O., & Zuniga, P. (2006). R&D and M&A: Are cross-border M&A different? An investigation on OECD countries. *International Journal of Industrial Organization*, *24*(2), 401–423. doi:10.1016/j.ijindorg.2005.07.006

7. Birkinshaw, J., Bresman, H., & Håkanson, L. (2000). Managing the post-acquisition integration process: How the human integration and task integration processes interact to foster value creation. *Journal of Management Studies*, *37*(3), 395–425. doi:10.1111/1467-6486.00186

8. Birkinshaw, J., Bresman, H., & Nobel, R. (2010). Knowledge transfer in international acquisitions: A retrospective. *Journal of International Business Studies*, *41*, 21–26. doi:10.1057/jibs.2009.71

9. Birkinshaw, J., & Gupta, K. (2013). Clarifying the distinctive contribution of ambidexterity to the field of organization studies. *The Academy of Management Perspectives*, *27*(4), 287–298.

10. Björkman, I., Stahl, G. K., & Vaara, E. (2007). Cultural differences and capability transfer in cross-border acquisitions: The mediating roles of capability complementarity, and social integration. *Journal of International Business Studies*, *38*(4), 658–672. doi:10.1057/palgrave.jibs.8400287

11. Bloomberg. (2014). *Global financial advisory mergers & acquisitions rankings 2013*. Retrieved from http://www.bloomberg.com/professional/content/uploads/sites/2/2014/01/M-and-A-2013.pdf

12. Buono, A. F., Bowditch, J. L., & Lewis, J. W. (1985). When cultures collide: The anatomy of a merger. *Human Relations*, *38*(5), 477–500. doi:10.1177/001872678503800506

13. Cartwright, S. (2012). Individual response to mergers and acquisitions. In D. Faulkner, S. Teerikangas, & R. J. Joseph (Eds.), *The handbook of mergers and acquisitions* (pp. 372–391). Oxford: Oxford University Press.

14. Cartwright, S., & Cooper, C. L. (1993). The role of culture compatibility in successful organizational marriage. *The Academy of Management Excecutives*, *7*(2), 57–70.

15. Cassiman, B., Colombo, M. G., Garrone, P., & Veugelers, R. (2005). The impact of M&A on the R&D process. *Research Policy*, *34*(2), 195–220. doi:10.1016/j.respol.2005.01.002

16. Cassiman, B., & Ueda, M. (2006). M&A and Innovation: A coneptual framework. In B. Cassiman & M. G. Colombo (Eds.), *Mergers and Acquisitions: The Innovation Impact* (pp. 63–76). Cheltenham: Edward Elgar Publishing Limited.

17. Chakrabarti, A., Hauschildt, J., & Süverkrüp, C. (1994). Does it pay to acquire technological firms? *R&D Management*, *24*(1), 47–56. doi:10.1111/j.1467-9310.1994.tb00846.x

18. Chatterjee, S., Lubatkin, M. H., Schweiger, D. M., & Weber, Y. (1992). Cultural differences and shareholder value in related mergers: Linking equity and human capital. *Strategic Management Journal*, *13*(5), 319–334.

19. Child, J., Faulkner, D., & Pikethly, R. (2001). *The management of international acquisitions*. Oxford: Oxford University Press.

20. Christensen, C. M., Alton, R., Rising, C., & Waldeck, A. (2011). The new M&A playbook. *Harvard Business Review*, (March), 48–57.

21. Cloodt, M., Hagedoorn, J., & Van Kranenburg, H. (2006). Mergers and acquisitions: Their effect on the innovative performance of companies in high-tech industries. *Research Policy*, *35*(5), 642–654. doi:10.1016/j.respol.2006.02.007

22. Cohen, W. M., & Levinthal, D. A. (1990). Absoprtive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly*, *35*(1), 128–152.

23. Cording, M., Christman, P., & King, D. R. (2008). Reducing causal ambiguity in acquisition integration: Intermediate goals as mediators of integration decisions and acquisition performance. *Academy of Management Journal*, *51*(4), 744–767.

24. Darr, E. D., & Kurtzberg, T. R. (2000). An investigation of partner similarity dimensions on knowledge transfer. *Organizational Behavior and Human Decision Processes*, *82*(1), 28–44. doi:10.1006/obhd.2000.2885

25. Datta, D. K. (1991). Organizational fit and acquisition performance: Effects of post-acquisition integration. *Strategic Management Journal*, *12*(4), 281–297.

26. De Man, A.-P., & Duysters, G. (2005). Collaboration and innovation: a review of the effects of mergers, acquisitions and alliances on innovation. *Technovation*, *25*(12), 1377–1387. doi:10.1016/j.technovation.2004.07.021

27. Ernst, H., & Vitt, J. (2000). The influence of corporate acquisitions on the behaviour of key inventors. *R&D Management*, *30*(2), 105–120.

28. Gates, S., & Very, P. (2003). Measuring performance during M&A integration. *Long Range Planning*, *36*, 167–185.

29. Gerpott, T. J. (1995). Successful integration of R&D functions after acquisitions: An exploratory study. *R&D Management*, *25*(2), 161–178.

30. Grant, R. M. (1996). Knowledge, strategy, and the theory of the firm. *Strategic Management Journal*, *17*, 109–129.

31. Grimpe, C., & Hussinger, K. (2013). Resource complementarity and value capture in firm acquisitions: The role of intellectual property rights. *Strategic Management Journal*, (August). doi:10.1002/smj

32. Häkkinen, L., Norrman, A., Hilmola, O.-P., & Ojala, L. (2004). Logistics integration in horizontal mergers and acquisitions. *The International Journal of Logistics Management*, *15*(1), 27–42.

33. Haspeslagh, P. C., & Jemison, D. B. (1991). *Managing acquisitions*. New York: The Free Press.

34. He, Z.-L., & Wong, P.-K. (2004). Exploration vs. exploitation: An empirical test of the ambidexterity hypothesis. *Organization Science*, *15*(4), 481–494. doi:10.1287/orsc.1040.0078

35. Hitt, M. A., Harrison, J., Ireland, R. D., & Best, A. (1998). Attributes of successful and unsuccessful acquisitions of US firms. *British Journal of Management*, *9*, 91–114. Retrieved from http://doi.wiley.com/10.1111/1467-8551.00077

36. Hitt, M. A., Hoskisson, R. E., Ireland, R. D., & Harrison, J. S. (1991). Effects of acquisitions on R&D inputs and outputs. *The Academy of Management Journal*, *34*(3), 693–706.

37. Hitt, M. A., Hoskisson, R. E., Johnson, R. A., & Moesel, D. D. (1996). The market for coporate control and firm innovation. *The Academy of Management Journal*, *39*(5), 1084–1119.

38. Homburg, C., & Bucerius, M. (2005). A marketing perspective on mergers and acquisitions : How marketing integration affects postmerger. *Journal of Marketing*, *69*(January), 95–113.

39. Homburg, C., & Bucerius, M. (2006). Is speed of integration really a success factor of mergers and acquisitions? An analysis of the role of internal and external relatedness. *Strategic Management Journal*, *27*, 347–367. doi:10.1002/smj.520

40. Hoskisson, R. E., & Hitt, M. A. (1990). Antecedents and performance outcomes of diversification: A review and critique of theoretical perspectives. *Journal of Management*, *16*(2), 461–509.

41. Kale, P., & Singh, H. (2007). Building firm capabilities through learning: The role of the alliance learning process in alliance capability and firm-level alliance success. *Strategic Management Journal*, *28*(December 2006), 981–1000. doi:10.1002/smj

42. King, D. R., Covin, J., & Hegarty, W. H. (2003). Complementary resources and the exploitation of technological innovations. *Journal of Management*, *29*(4), 589–606. doi:10.1016/S0149-2063(03)00026-6

43. King, D. R., Dalton, D. R., Daily, C. M., & Covin, J. G. (2004). Meta-analyses of post-acquisition performance: Indications of unidentified moderators. *Strategic Management Journal*, *25*, 187–200. doi:10.1002/smj.371

44. King, D. R., Slotegraaf, R. J., & Kesner, I. (2008). Performance implications of firm resource interactions in the acquisition of R&D-intensive firms. *Organization Science*, *19*(2), 327–340. doi:10.1287/orsc.1070.0313

45. Kretschmer, T., & Puranam, P. (2008). Integration through incentives within differentiated organizations. *Organization Science*, *19*(6), 860–875.

46. Krishnan, H. A., & Park, D. (2002). The impact of work force reduction on subsequent performance in major mergers and acquisitions: An exploratory study. *Journal of Business Research*, *55*, 285–292. doi:10.1016/S0148-2963(00)00166-1

47. Lakshman, C. (2011). Postacquisition cultural integration in mergers & acquisitions: A knowledge- based approach. *Human Resource Management*, *50*(5), 605–623. doi:10.1002/hrm

48. Larsson, R., & Finkelstein, S. (1999). Integrating strategic, organizational, and human resource perspectives on mergers and acquisitions: A case survey of synergy realization. *Organization Science*, *10*(1), 1–26.

49. Larsson, R., & Lubatkin, M. (2001). Achieving acculturation in mergers and acquisitions: An international case survey. *Human Relations*, *54*, 1573–1607. Retrieved from http://hum.sagepub.com/cgi/doi/10.1177/00187267015412002

50. Makri, M., Hitt, M. A., & Lane, P. J. (2010). Complementary technologies, knowledge relatedness, and invention outcomes in high technology mergers and acquisitions. *Strategic Management Journal*, *31*, 602–628. doi:10.1002/smj

51. March, J. G. (1991). Exploration and exploitation in organizational learning. *Organization Science*, *2*(1), 71–87.

52. Martinez, J. I., & Jarillo, C. J. (1991). Coordination demands of international strategies. *Journal of International Business Studies*, *1*(3), 429–444.

53. Nahapiet, J., & Ghoshal, S. (1998). Social capital, intellectual capital, and the organizational advantage. *The Academy of Management Review*, *23*(2), 242–266.

54. Nielsen, B. B., & Gudergan, S. (2012). Exploration and exploitation fit and performance in international strategic alliances. *International Business Review*, *21*(4), 558–574. doi:10.1016/j.ibusrev.2011.07.001

55. Paruchuri, S., Nerkar, A., & Hambrick, D. C. (2006). Acquisition integration and productivity losses in the technical core: Disruption of inventors in acquired companies. *Organization Science*, *17*(5), 545–562. doi:10.1287/orsc.1060.0207

56. Podsakoff, P. M., MacKenzie, S. B., & Podsakoff, N. P. (2012). Sources of method bias in social science research and recommendations on how to control it. *Annual Review of Psychology*, *63*, 539–69. doi:10.1146/annurev-psych-120710-100452

57. Prabhu, J. C., Chandy, R. K., & Ellis, M. E. (2005). The impact of acquisitions on innovation: Poison pill, placebo, or tonic? *Journal of Marketing*, *69*(January), 114–130.

58. Puranam, P., Singh, H., & Chaudhuri, S. (2009). Integrating Acquired Capabilities: When Structural Integration Is (Un)necessary. *Organization Science*, *20*(2), 313–328. doi:10.1287/orsc.1090.0422

59. Puranam, P., Singh, H., & Zollo, M. (2006). Organizing for innovation: Managing the coordination-autonomy dilemma in technology acquisitions. *The Academy of Management Journal*, *49*(2), 263–280. doi:10.5465/AMJ.1962.5065118

60. Quah, P., & Young, S. (2005). Post-acquisition management: A phases approach for cross-border M&As. *European Management Journal*, *23*(1), 65–75. doi:10.1016/j.emj.2004.12.010

61. Ranft, A. L., & Lord, M. D. (2002). Acquiring new technologies and capabilities : A grounded model of acquisition implementation. *Organization Science*, *13*(4), 420–441.

62. Reus, T. H., & Lamont, B. T. (2009). The double-edged sword of cultural distance in international acquisitions. *Journal of International Business Studies*, *40*, 1298–1316. doi:10.1057/jibs.2009.25

63. Riketta, M. (2005). Organizational identification: A meta-analysis. *Journal of Vocational Behavior*, *66*(2), 358–384. doi:10.1016/j.jvb.2004.05.005

64. Sarala, R. M., & Vaara, E. (2010). Cultural differences, convergence, and crossvergence as explanations of knowledge transfer in international acquisitions. *Journal of International Business Studies*, *41*, 1365–1390. doi:10.1057/jibs.2009.89

65. Sarkar, M., Echambadi, R., Cavusgil, S. T., & Aulakh, P. S. (2001). The influence of complementarity, compatibility, and relationship capital on alliance performance. *Journal of the Academy of Marketing Science*, *29*(4), 358–373. doi:10.1177/03079450094216

66. Schoenberg, R. (2003). Mergers and acquisitions. Motives, value creation, and implementation. In D. Faulkner & A. Campbell (Eds.), *The Oxford Handbook of Strategy: A strategy overview and competitive strategy* (pp. 587–648). Oxford: Oxford University Press.

67. Schweiger, D. M., & Goulet, P. K. (2005). Facilitating acquisition integration through deep-Level cultural learning interventions: A longitudinal field experiment. *Organization Studies*, *26*(10), 1477–1499. doi:10.1177/0170840605057070

68. Schweizer, L. (2005). Organizational integration of acquired biotechnology companies into pharmaceutical companies: The need for a hybrid approach. *Academy of Management Journal*, *48*(6), 1051–1074. Retrieved from http://amj.aom.org/cgi/doi/10.5465/AMJ.2005.19573109

69. Shrivastava, P. (1986). Post-merger integration. *The Journal of Business Strategy*, *7*(1), 65–76.

70. Slangen, A. H. L. (2006). National cultural distance and initial foreign acquisition performance: The moderating effect of integration. *Journal of World Business*, *41*(2), 161–170. doi:10.1016/j.jwb.2006.01.003

71. Stahl, G. K., & Voigt, A. (2008). Do cultural differences matter in mergers and acquisitions? A tentative model and examination. *Organization Science*, *19*(1), 160–176. doi:10.1287/orsc.1070.0270

72. Teerikangas, S., & Joseph, R. J. (2012). Post-deal integration. An overview. In D. Faulkner, S. Teerikangas, & R. J. Joseph (Eds.), *The handbook of mergers and acquisitions* (pp. 339–371). Oxford: Oxford University Press.

73. Teerikangas, S., & Very, P. (2006). The culture-performance relationship in M&A: From yes/no to how. *British Journal of Management*, *17*, S31–S48. doi:10.1111/j.1467-8551.2006.00477.x

74. Van Dick, R., Ullrich, J., & Tissington, P. A. (2006). Working under a black cloud: How to sustain organizational identification after a merger. *British Journal of Management*, *17*(S1), S69–S79. Retrieved from http://doi.wiley.com/10.1111/j.1467-8551.2006.00479.x

75. Vermeulen, F., & Barkema, H. (2001). Learning through acquisitions. *The Academy of Management Journal*, *44*(3), 457–476.

76. Very, P., Lubatkin, M., Calori, R., & Veiga, J. (1997). Relative standing and the performance of recently acquired european firms. *Strategic Management Journal*, *18*(8), 593–614.

77. Walsh, J. P. (1988). Top management turnover following mergers and acquisitions. *Strategic Management Journal*, *9*(2), 173–183.

78. Weber, Y., Shenkar, O., & Raveh, A. (1996). National and corporate cultural fit in mergers/acquisitions: An exploratory study. *Management Science*, *42*(8), 1215–1227.

79. Weber, Y., Tarba, S. Y., & Bachar, Z. R. (2011). Mergers and acquisitions performance paradox: The mediating role of integration approach. *European Journal of International Management*, *5*(4), 373–393.

80. Zhou, K. Z., & Li, C. B. (2012). How knowledge affects readical innovation: Knowledge base, market knowledge acquisition, and internal knowledge sharing. *Strategic Management Journal*, *33*(January), 1090–1102. doi:10.1002/smj

81. Zollo, M., & Singh, H. (2004). Deliberate learning in corporate acquisitions: Post-acquisition strategies and integration capability in U.S. bank mergers. *Strategic Management Journal*, *25*, 1233–1256. doi:10.1002/smj.426

APPENDIX

Construct Measurements

Construct	Item	Individual item reliability	Cumulative % of squared loadings	Cronbach's alpha
Human Integration	Organizational structure	0.830	73.945	0.824
	Organizational culture	0.863		
	HR management	0.886		
Task Integration	Production integration	0.877	68.051	0.764
	Marketing integration	0.855		
	Systems integration	0.736		
Production integration	- Production	0.886	78.561	0.726
	- Supply sources	0.886		
Marketing integration	- Distribution channels	0.858	76.592	0.847
	- Sales/after-sales services	0.883		
	- Marketing programs	0.884		
Systems integration	- Strategic planning systems	0.858	75.929	0.841
	- Financial & budget systems	0.883		
	- Managemet information systems	0.873		
Upstream Performance	- Exchange of technology and know-how for specific product categories	0.892	79.526	0.740
	- Increase of not planned product or process innovation	0.892		

LEAN SIX SIGMA STRATEGY: A CASE STUDY FROM SWEDEN

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ABSTRACT

Purpose: The aim is to examine if the joint-use strategy of Lean Six Sigma can improve flexibility, robustness, cost-efficiency, and agility at the same time.

Design/methodology/approach: A single case study including a Swedish company from the telecom manufacturing industry was conducted.

Findings: A Lean Six Sigma strategy ensures more flexible, robust, and efficient processes. However, to make them agile, something more is required. This could include training the staff, strengthening company culture and collaborating with key partners in the supply chain.

Research limitations/implications: This study is limited to large companies that usually have a lot of resources and choices where to put the strategic emphasis. The situation could be very different in small and medium-sized companies.

Practical implications: This research provides guidance on how to manage the Lean Six Sigma strategy in order to ensure more flexible, robust, and efficient processes.

Originality/value: This research provides guidance to companies regarding the applicability and properties of the Lean Six Sigma strategy.

Keywords: Lean, Six Sigma, Telecom manufacturing

Paper type: Case study

INTRODUCTION

The joint-use strategy of Lean Six Sigma recently has appeared in the literature (George and Wilson, 2004). Nowadays, these two strategies have been effectively integrated (George et al., 2004). The Lean strategy takes care of waste across all processes and focuses on speed

and time, whereas the Six Sigma strategy focuses on design, eliminating defects, driving out process variability as well as reducing costs. The Six Sigma strategy gives extra value to the Lean strategy, since it squeezes out variability in time. Lead-times become more reliable and safety stock levels can be reduced (Christensen et al., 2007). Thus, the Lean Six Sigma strategy offers a solution that creates more flexible, robust, and cost-efficient processes.

Nowadays, something more than fast delivery and high quality at a minimal cost is needed to be successful in the market. Firms must have a balanced combination of objectives as well as satisfy dissimilar customer needs that rapidly changes with cost control, much in line with the agile strategy. Agility is a relatively new strategy and represents a more holistic attribute than flexible. Agile means being able to react fast when something unusual happens, or being successful in unpredictable, uncertain, and changing environments (Schrage, 2004).

The four attributes of flexibility, robustness, agility, and cost-efficiency are often in conflict. Still, if they are in conflict, it is important to decide how flexible, robust, and agile a company should be to be competitive and profitable. The critical issue is variability in the processes. If everything were absolutely constant or even expected, then there would be no problems. On the other hand, if variability can be reduced, the output can be guaranteed through a robust process. However, striving for agility will often induce more variability. The basic approach is then to eliminate or control variability.

This led us to elaborate, whether the Lean Six Sigma strategy could fulfill all these four requirements. The specific research question is: "Can the joint-use strategy of Lean Six Sigma improve flexibility, robustness, cost-efficiency, and agility at the same time?". This issue has been examined through a single case study including a Swedish company from the telecom manufacturing industry (Ericsson). In particular, a Six Sigma project has been followed and thoroughly analyzed during 2002, mainly through in-depth and semi-structured interviews with key persons representing senior and middle management in the case company. However, the outcome of the Six Sigma project has been studied in longitudinal manner until 2014.

THEORETICAL FOUNDATION

The main components of Lean are stable and standardized methods of working, making all employees involved and committed, keeping a focus on what the customer really wants, delivering the right quality at the right time, at a minimum cost (Pascal, 2002). Lean is fundamentally customer value driven and is a continuous improvement process, in small steps, which makes it appropriate for many manufacturing and distribution situations. Lean includes five phases (McCurry and McIvor, 2001; Bicheno, 2004)

1. **Understanding customer value**: Only what the customers perceive as value is important. The customers could be the next process, the next company, the customer´s customer or the end customer.

2. **Value stream analysis**: Having understood the value for the customers, the next step is to analyse the business processes to determine which ones actually add value. The value stream should be mapped and improved regularly. If an action does not add value, it should be modified or eliminated from the process.

3. **Flow**: Focus on organising a continuous flow through the production. If possible use one-piece flow, rather than moving commodities in large batches and keep it moving. Avoid queues, or at least continuously reduce them and the obstacles in the way.

4. **Pull**: Pull means short-term response to the customer´s rate of demand, without over-producing. Level one is that most organisations will have to push the products to a certain point and after that respond to the final customer's signal, the idea is to push this point further and further upstream. Level two is responding to a pull signal from an internal customer, within the value chain, for this often a Kanban system is used. Pull needs to take the whole demand flow network in consideration, not only within the company.

5. **Perfection**: The elimination of non-value-adding elements (waste) is a process of continuous improvement. According to McCurry and McIvor (2001), "There is no end to reducing time, cost, space, mistakes, and effort". Often a systematic approach is used for continuous improvement.

These five phases are not a sequential, one-off procedure, but rather a journey of continuous improvement (Bicheno, 2004; McCurry and McIvor, 2001).

The main components of Six Sigma are a clear infrastructure, fact-based decisions, effective and efficient methods and tools, systematic follow-up and feedback on results, broad training programmes, and uniform procedures for improvement and design of products, processes and systems. A central aspect is committed leadership on all levels (Henderson and Evans, 2000). There are two types of improvement cycles in Six Sigma: one for existing processes and one for new products (Pyzdek, 2003). The improvement cycle of existing processes (DMAIC) includes five phases (Magnusson et al., 2003):

1. **Define:** Identify the process or product that needs improving. Find the most capable persons for involvement in the project. Define customers and stakeholders and find out about their needs and expectations. Design a process map, identify the current base line and select SMART goals. Set up a communication strategy. Design a time & resource plan and carry out a risk analysis for the project. Finally construct a project chart.

2. **Measure:** Identify potential root causes; establish what effect they have on the process and how they are to be measured. Investigate the capability of the measurement system. Identify suitable benchmarking partners.

3. **Analyze:** Analyze the root causes and the factors that need improving. Find areas that need to be addressed.
4. **Improve:** Design the most effective and efficient solution. Perform cost/savings and risk analyses of solutions and construct a plan for resource allocation and implementation. Make the process robust.
5. **Control:** Establish whether the chosen solution proved successful and permanent. Validate the result against the goal statement and investigate whether the solution is robust. Transfer responsibility, share learning and best practice.

In the DMAIC cycle, the focus is on variability, saving money and achieving company objectives (Andersson et al., 2006). It is a modification of the PDCA cycle (Plan, Do, Check, and Act), with complementary addition tools and methods for improvement work. The PDCA cycle originates from Deming and Shewhart, besides being used in Lean.

RESEARCH APPROACH

The case study was conducted at one of the production facilities in the Ericsson Group located in Borås (Sweden). An improvement project was identified together with the senior management of the production facility. A decision was taken to study the assembly and testing processes of the MINI-LINK production line (push system). A Six Sigma project was initiated and carried out according to the DMAIC cycle and the outcome of this project is reported in this research work.

The product MINI-LINK is used for transmitting data into the air (between two pylons). MINI-LINK is available at a frequency range between 6 and 80 GHz, and capacity up to 1 Gbps. The frequency band is divided into a large number of "sub-bands" (small frequency ranges) and the product is therefore available for the customers in a great variety of variants. Since customization must be done before delivery, the products cannot be stored. Hence lead-time and delivery precision are vital to meeting customer demands.

Empirical data has been collected during 2002, from on-site interviews with staff members who work in the targeted processes. Data was also collected through observations as well as from internal documents. More than 5,000 observations were made from each process during two months. These observations were considered to be representative for the rest of the year. After the improvement project ended the data collection has contained on an annual basis until 2014. In other words, the authors have followed the improvements and the outcomes at annual basis in over 10 years. The data in the figures below was collected at the production line in Ericsson Borås using local production system as source.

CASE STUDY FINDINGS

Define Phase

A problem statement was made, as well as an analysis of profitability. The lead-time was 80 hrs for 98% of the products; the median was 42 hrs, or 66% within 72 hrs and only 47% within 48 hrs. The measurements were based on a production volume of 900 units a week during four shifts.

Having set waiting time at a perceived reasonable level, using the SMART (Specific, Measurable, Accepted, Reasonable and Time Set) method of setting targets and then simulating values. Figure 1 shows a simulation of a reasonable value for future lead times. The optimal value of the lead-time is 48 hrs or less for 98% of the products. The simulation was built using both simulated and actual data for the 2995 samples. For each sample, data for each component was established as a sum of all components (Figure 3). For each buffer component an expected value was used together with an exponential distribution to create a simulated value. For each sub-process a distribution was calculated using real-life data from production line as a base and then this distribution was used in Minitab to create a simulated value. Each of these simulated values was summarized and then gives the total simulated lead-time for each sample.
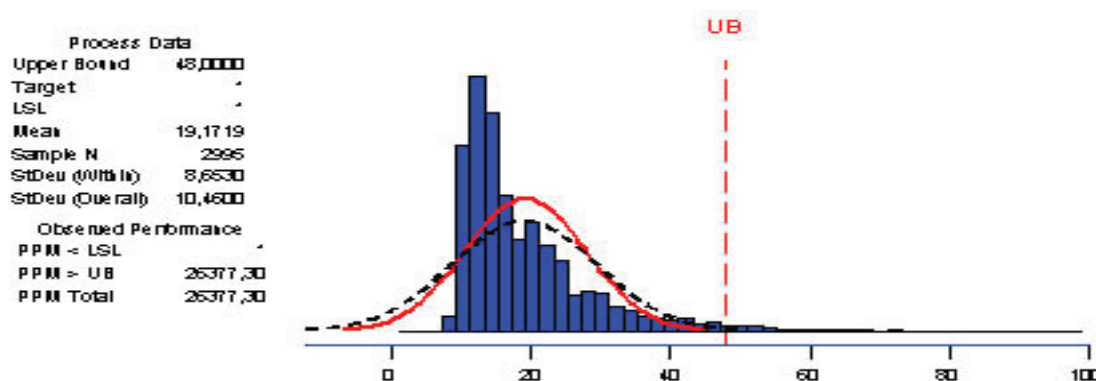
Figure 1. Simulated lead time for a future possible state

The simulations also show that at least five business objectives would be improved at a low cost. If products in process are reduced to a reasonable level, the average lead-time will be 20 hrs for the products. These arguments are strong enough to warrant the project. The improvement aims at fulfilling a customer delivery precision of 99 %.

A SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis was made and stakeholders were identified. VOCs (Voice of Customers) were then identified, their requirements broken down to CTQ (Critical to Quality parameters). Next a project plan was

constructed. To achieve a better understanding of the process, a SIPOC (Supplier Input Process Output Customer) was carried out, and a process map designed (Figure 2).

Measure Phase

After brainstorming and discussion with regard to how to identify potential root causes; establish what effect they have on the process, and how they are to be measured, the following were found to be of interest:

- The order in which the products were assembled.
- Waiting time before the assembly and calibration processes, the temperature and system tests.
- The repairs and waiting times for the products arriving from the calibration process, temperature test and system test.
- Variability and inventory levels of the products before the calibration process, temperature test and system test.
- The measurement system analysis of the data indicated that the reliability and validity data were acceptable.
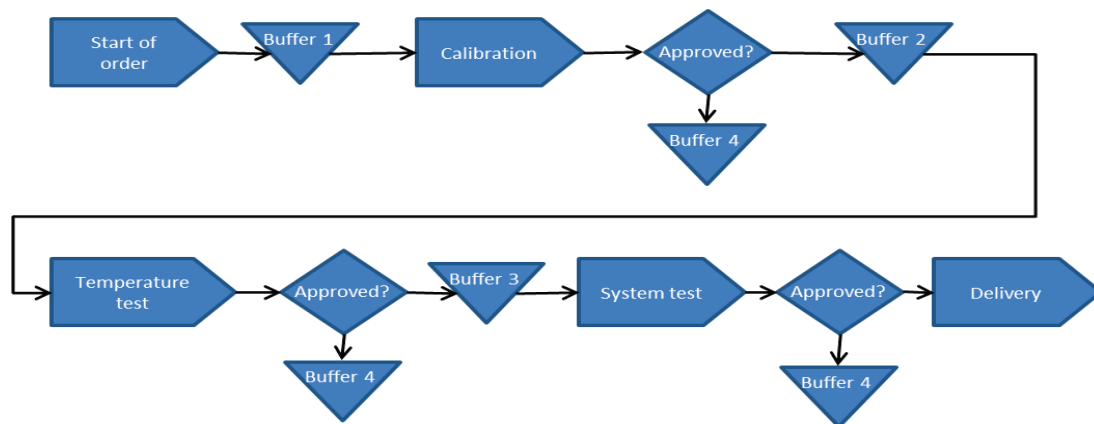
Figure 2. Process map of the system
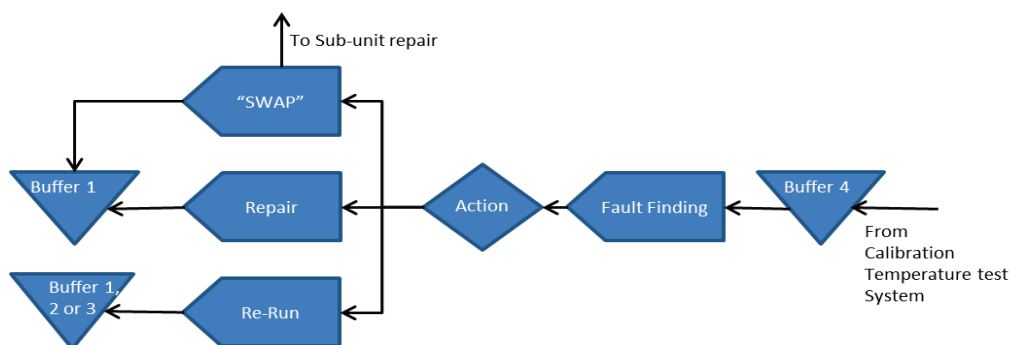
Figure 3. The new repair process

Analyze Phase

The next step was to analyze the factors and find areas that need to be addressed in Measure phase in order to find the root causes. The analysis of the order in which the products were assembled showed only one accurate assembly out of five of the correct MINI-LINK to the same index pair.

An analysis of calibration consistency of index pairs in line was also carried out. When there are faulty components in the system, disorder in the system is created, resulting in decreased same-index reliability. This leads to an increased inventory level before calibration. The disorder is further increased in subsequent processes.

The next step was to look into waiting times within the assembly process, as well as in the calibration process and the system test. Median values for waiting times were increased further into the system. Median waiting time before calibration test was 1.9 hrs, before temperature test 4.9 hrs and before system test 8.5 hrs.

Repair time (Rt), is waiting time before repair of the products after calibration, temperature test and system test (Buffer 4, see Figure 3). The products which did not pass calibration had a median value of 24 hrs, i.e. waiting time before repair, time to repair and time to transport the product into the system. The values for the temperature test and system test were 60 hrs and 1.5 hrs, respectively. The long duration of the temperature test is due to the fact that the MINI-LINK cannot proceed to temperature test before the oven is filled up. Variability was large for getting the MINI-LINK repaired at calibration. Similar variability appeared at temperature and system test repair.

Store levels and variability before calibration, temperature test and system test were set. The median value of MINI-LINK storage was 18 units between assembly and calibration, 29 units between calibration and temperature test and 50 units between temperature test and system test. The rate of variability is increased further into the system (Figure 4).
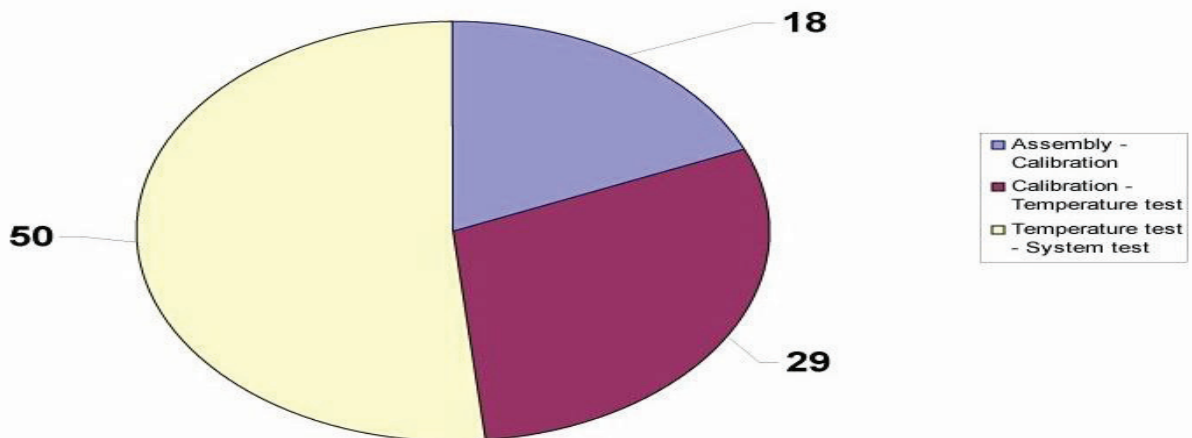
Figure 4. The median value of store levels between the different processes

Variability in different store levels between temperature test and system test. The median stock value was 50 units; two distributions can be discerned (Figure 5).

After analyzing the present situation, finding the root causes and trying to predict a future design, the next step was to design the most effective and efficient solution in order to make the process robust and flexible. By using Lean and Six Sigma tools and methods the following changes were to be implemented:

- Modification of the start routine, so that products with the same index would be started in sequence.
- Customer-driven start of the right index, with regard to products in the system.
- Identification of an optimal starting time in temperature tests.
- Store level before calibration to be two units per test site.
- Special transport wagons to be made for a Kanban system.
- Store level before temperature test to be four positions and two transport wagons.
- Store level before system test to be two transport wagons. Priorities to be made in conjunction with temperature test, ensuring that the right index pair is transported.
- At repairs: MINI-LINKS straight from temperature test to be given priority, and to be back in the system within four hours.
- A staff rotation system to be introduced at test sites in order to improve flexibility.
- Calibration staff to receive training in how to install and start units in temperature tests.
- A new layout of the system to be made.
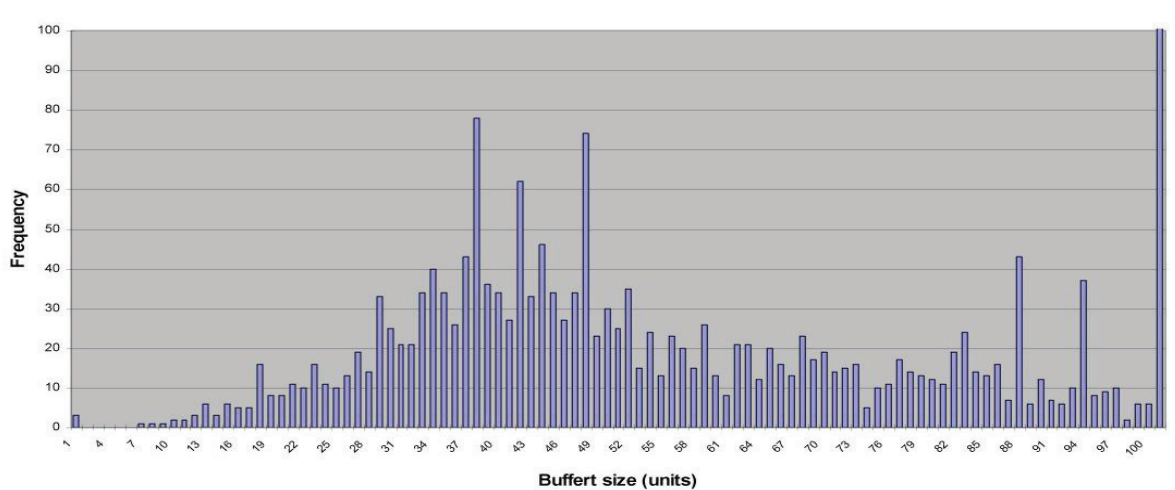
Figure 5. Variability in different store levels between temperature test and system test Perform cost/savings and risk analyses of solutions and construct a plan for resource allocation and implementation, the next step was to implement.

Improve Phase

After implementation, the outcome was that the products in the process were reduced by 50 units. Reducing the number of products in process leads to visibility of problems in the system, which also results in further improvement, e.g. putting a stop to picking when the buffer stock exceeds 12 units, and asking for help, when the buffer stock is below 6 units, which make the process more robust and flexible.

Internal transportation distance of the MINI-LINK was decreased and walking time for employees was cut and after base decision on fact by having calculated tact time, some staff could be given other duties. After interviews with the staff, the main conclusions were that the environment had been much improved. There was considerably less stress, the atmosphere was more cheerful, the staff was more proud of and satisfied with their work, and the number of accidents was reduced. Thanks to the removal of the lift machines, the staff was very positive to the new and improved work place. Proximity between employees made for better communication, creating a more pleasant atmosphere and a quicker response to any problems cropping up. Fewer products in work and less staff reduced stress among staff, and also all employees could perform each other's routines. In case of a new incoming product-family order, or a changed starting order of a MINI-LINK index, the performance of the system did not deteriorate, which the case was before. The result of all these implementation gave a system that was more reliable, robust, flexible and in line with an agile system.
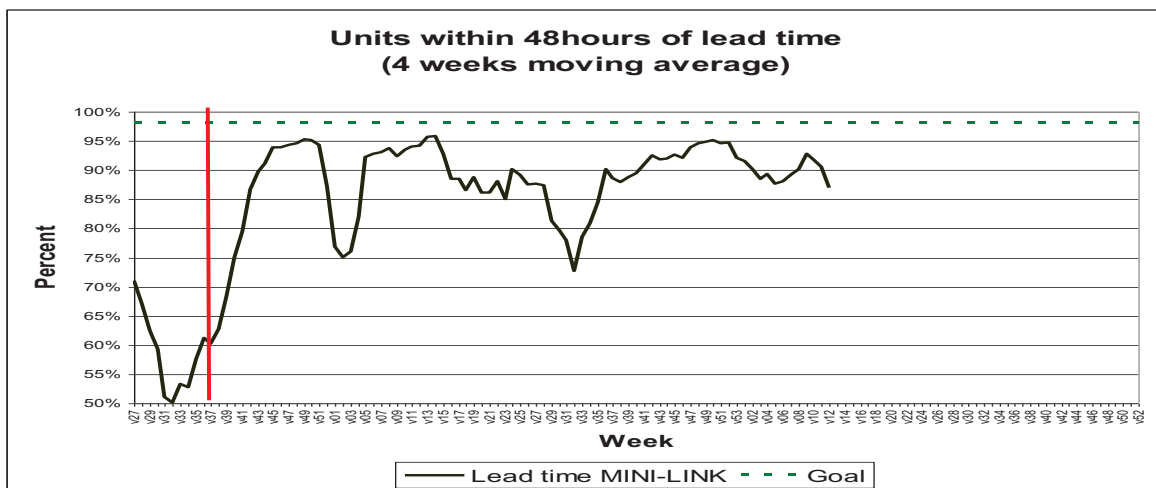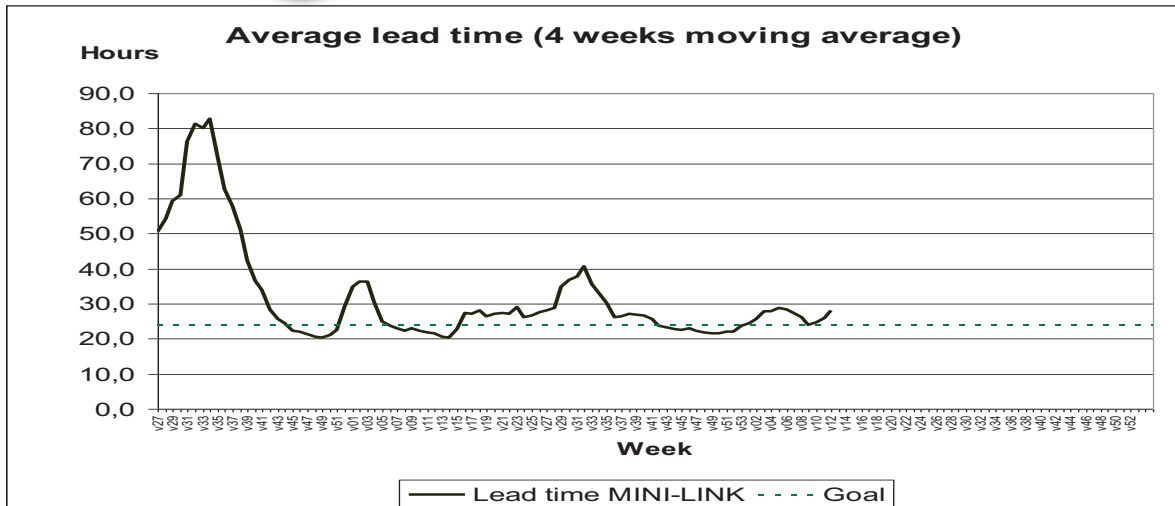
Figure 7. Percent of the units within 48 hrs
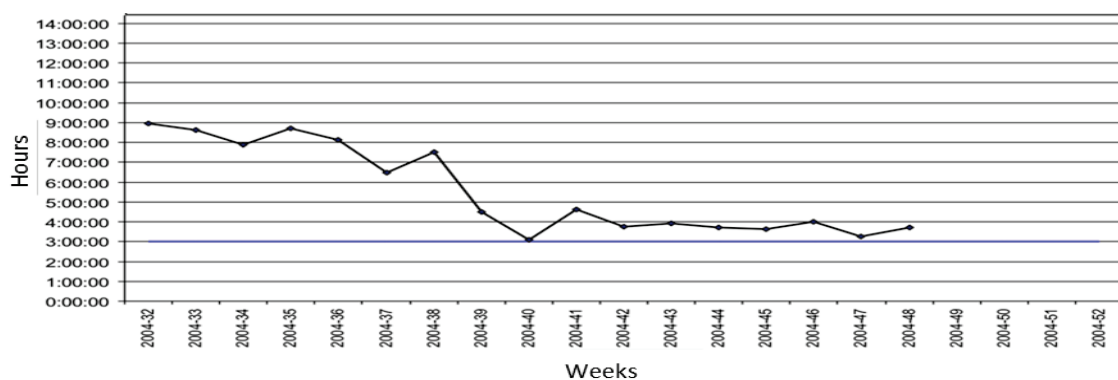
Figure 8. The time for the repair process

Other quantitative results were that refinement time was considerably reduced and delivery precision was secured and the lead time was decreased from 80 hrs for 98% of the products to 48 hrs or less for 98% of the products. One of the objectives was to reduce lead-time to 48

hrs for 98% of the products. The chart shows that delivery precision was improved, but not to 98%. Continuous improvement might achieve the target (Figures 6-8).

Before the above-mentioned changes were implemented, the repairs process was critical. After changing the routine and the flow, waiting time was decreased, i.e. the products were back in the system much sooner. The chart shows that the values were improved over time, due to the introduction of the last phase of the Lean concept, Perfection, i.e. continuous (step by step) improvement, visualizing management systems and adopting preventive maintenance routines (Figure 8).

Calibration was a bottleneck. In this process waiting time must be low for the right index pair. The optimal amount of warming sites was calculated using simulation of old data. Data from the three processes were explained as normal distribution for the assembly process, exponential distribution for the warming site and Weibull distribution for the calibration process. Using simulation, the optimal amount of units at warming sites was fixed at a minimum of eight, with a risk of less than 1% of there being a unit ready for calibration (Figure 9).

Simulated buffer size

	1	2	3	4	5	6	7	8	9	10
Accumulated probability	100%	92%	70%	44%	21%	8%	2%	0,4%	0,1%	0,0%

Number of units needed in buffer
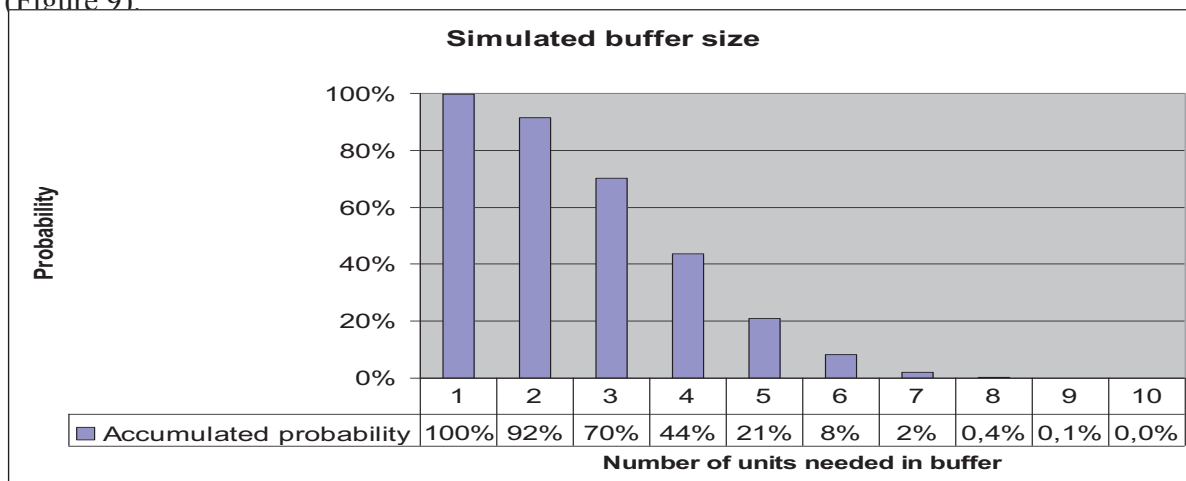
Figure 9. Number of units in the calibration process

Total savings per annum exceeded 1 million euros after implementing all and finishing the improve phase.

Control Phase

Team building was introduced to promote shared values. Training sessions were to be held twice a year, and stand-up meetings introduced between each shift to further strengthen shared values and team spirit. To improve results over time, the following criteria of the Lean philosophy were introduced: continuous (step by step) improvement (PDCA cycle was introduces), Total Preventive Maintenance (TPM), application of Visual Management System (VMS) three times a day, removal of additional waste, and visualization routines.

Proceedings of 2014 International Conference on
Technology Innovation and Industrial Management
28th-30th May 2014, Seoul, South Korea

CONCLUDING REMARKS

This research aimed to examine if the Lean Six Sigma strategy can improve flexibility, robustness, cost-efficiency, and agility at the same time. The conducted improvement project made the studied processes more flexible, robust and cost-efficient, moving closer towards agile. In addition, the processes became more reliable because of preventive maintenance, continuous improvement, and self-governing teams. A simulated trial showed that a new product family could be introduced into the production line without an increase in the total lead-time. The insertion of an extra shift, due to increased production volumes, also is not a problem since the workers are familiar with each other's routines.

The same results would have been very difficult to achieve if only the Lean or Six Sigma strategy had been used. One reason for this is that the Lean strategy focuses on value stream mapping, where process variability usually does not emerge. Possibly, the same excellent results could be reached without using the Six Sigma strategy since the last phase in the lean strategy is about long term perfection, however, this would take a very long time. Another reason why it would have been difficult to achieve the same results is that the Six Sigma strategy includes a better framework for project management, providing project members with comprehensive training and a clear project management structure, as well as middle management involvement and a result orientation from senior management.

The result shows that the Six Sigma strategy is suitable for making processes more flexible, robust, and cost-efficient. However, when the Six Sigma project is finished, the last phase of the Lean strategy (perfection) is appropriate to make the process flexible, robust, and efficient over time. This phase includes waste removal, preventive maintenance, visual management system, continuous improvement, and self-governing teams. Therefore, the Lean Six Sigma strategy ensures more flexible, robust, and cost-efficient processes over time. However, to make the processes agile to sustain in changing environment, requires something more. This could include training the staff, strengthening the company culture, and collaborating with the key partners in the supply chain.

REFERENCES

1. Andersson, R., Eriksson, H., and Torstensson, H. (2006) Similarities and differences between TQM, Six Sigma and Lean, The TQM Magazine, 18(3), 282-296.
2. Bicheno, J. (2004) The new lean toolbox, towards fast, flexible flow. Buckingham: PICSIE Books.
3. Christensen W., Germain R., and Birou L. (2007) Variance vs. average: supply chain lead-time as a predictor of financial performance, Supply Chain Management: An International Journal, 12(5), 349–357.
4. George, M.L., and Wilson, S.A. (2004) Conquering Complexity in Your Business. New York: McGraw-Hill.

5. George, M.L., Rowlands, D., and Kastle, B. (2004) What is Lean Six Sigma? New York: McGraw-Hill.

6. Henderson, K., and Evans, J. (2000) Successful Implementation of Six Sigma. Benchmarking General Electric Company, <u>Benchmarking: An International Journal</u>, 7(4), 260-281.

7. McCurry L., and McIvor, R.T. (2001) Agile Manufacturing, 21st Century Strategy for Manufacturing on the Periphery? Irish Academy of Management Conference, University of Ulster.

8. Magnusson, K., Kroslid, D., and Bergman, B. (2003) Six Sigma - The Pragmatic Approach. Lund: Studentlitteratur.

9. Pascal, D. (2002) Lean Production Simplified. New York: Productivity Press.

10. Paton, D., Smith, L., and Violanti, J. (2000) Disaster response: risk, vulnerability and resilience, <u>Disaster, Prevention and Management</u>, 9(3), 173-179.

11. Pyzdek, T. (2003) The Six Sigma Handbook. New York: McGraw-Hill.

12. Schrage, M. (2004) The Struggle to Define Agility, <u>CIO Magazine</u>, August 15.

13. Sheffi, Y. (2007) The resilient enterprise: overcoming vulnerability for competitive advantage. Cambridge: MIT.

THE EFFECTS OF EXPERIENCES, TRUST, NETWORKS, AND INTUITION ON SWISS SMEs' DECISION TO INTERNATIONALIZE

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ABSTRACT

Despite a wealth of literature on the internationalization of small and medium-sized businesses (ESNR, 2003; EIM Business & Policy Research, 2010 and 2011; OECD, 2004; IHK Bochum, 2010), there still is little awareness of its origins and the actual moment of deciding in favour of internationalization. At the same time, it can be assumed that the main factors deciding the success or failure of the SMEs' venture will also have their origins there. A look at current research shows that "international performance" or the opportunities and risks it brings for SMEs has been researched in Switzerland (Baldegger, 2010 and 2013; Credit Suisse, 2010), but no attention has yet been given to a perspective that covers in particular the decision-making process, the qualities of the decisions, and the factors influencing them. Our study, conducted in November/December 2013, focuses on these decisions by Swiss SMEs and tries to fill that gap in our knowledge. Its aim is to contribute to creating more awareness and professionalism in this early phase of internationalization processes which seems essentially relevant for the later course of the processes. Considering the findings of our study, it can be said that trust-oriented, network-based, and intuitive factors (competences / abilities / characteristics / attitudes) play a major role in these internationalization decisions. The option of taking the business international has always been present among Swiss SMEs, but can only be seized in practice if both the decision-makers and the organizations themselves possess the mentioned characteristics, recognize their potential, and act upon it. Internationalization is possible without this, but the question has to be whether the decision to internationalize can then achieve the same level of quality if it does not put to use all of the available factors (experience, trust, networks, and intuition.

Classification: Research Paper

PURPOSE AND PRESENTATION OF THE MODEL

The wave of internationalization has long caught Swiss SMEs in its wake (Switzerland Global Enterprise 2012), forcing them to face the question of whether and how to take their business global. Such an internationalization decision can (ex post) be considered a "critical juncture" (Collier/Collier 1991; Schreyögg/Sydow/Koch 2003; Capoccia/Kelemen 2007), since it will usually initiate a new and lasting change in the now internationalized organizations. When looking for means of support for such a momentous decision, SMEs can take recourse to the established theories and models of internationalization decisions (such as Holtbrügge 2005, who references the Uppsala model). In practical terms, larger companies or multinational enterprises that have already successfully internationalized their business can serve as models (for larger companies' experience with internationalization, cf. Casson 2009). Compared to their small and medium-sized counterparts, however, such companies operate with far different structural resources and conditions to shape the decision-making process and balance the ambiguities that come along with it. In most instances, larger companies possess the financial and human resources as well as the competences and first-hand experience that can offer additional rational safeguards for the decision-making process. They can apply a battery of indicators, models, and scenarios to assess their internationalization options. Their resources also allow them to approach such decisions in a safer sequential process that mitigates possible risks. This situation immediately reveals that SMEs cannot hope to simply emulate the processes used by their larger peers, even though they are facing the same basic conundrum (To internationalize or not to internationalize? If so, how?).

We assume that SMEs are forced to take recourse to other sources than their larger peers are wont to use when preparing their decisions (cf. e.g. Glückler 2006; Crick/Spence 2005). In this respect, the following resources are deemed relevant: The personal competences and experiences of the decision-makers, the networks into which they are integrated, and the trust and belief in themselves and their abilities as decision-makers (Schreier/Dievernich/Gong 2013), in their experiences and their networks, and in their own intuition, commonly referred to as "gut feeling". Relying on such resources should not be regarded as a less rational approach than the methods favoured by larger organizations, although the paper stresses that a *different* form of rationality is at work in SMEs. For them, the lack of meaningful resources and structures in itself can make it the rational choice to turn to other, more intuitive and personality-dependent resources to manage the ambiguity that is inherent to internationalization decisions.

Working with the basic assumption outlined here, we have developed an "emotion-based decision-making model" for SMEs' internationalization decisions (Dievernich/Schreier/Gong 2013), to be validated by means of an empirical investigation of Swiss SMEs. This study and its findings represent the core of this paper; it intends to open an innovative new vista in the current discourse about internationalization.[1]

The Emotion-Based Model for internationalization decisions outlined here was considered when defining the questions in the quantitative online questionnaire that our study is based on. These questions are derived from the following basic hypotheses of the model: 1. The international and intercultural experience of the decision-maker have an impact on the internationalization decision or the practical internationalization of the business; 2. The (perceived) trust of the decision-maker in his or her experience, private and/or professional networks, and his or her intuition influences the internationalization decision or actual internationalization; 3. Private and/or professional networks and contacts of the decision maker influence the internationalization decision and actual internationalization; 4. The intuition of the decision-maker has an influence on his or her internationalization decision or the eventual internationalization of the business. Despite the neutral (neither positive nor negative) phrasing of the hypothesis, we are interested in seeing whether the participants recognize any links between these and the perceived success of internationalization ventures or whether there is a correlation in terms of the control question about internationalization efforts experienced as positive.

The basic assumption is that internationalization decisions are unavoidably associated with insecurity. This risk leads to an emotional need to reduce the resulting uncertainty. We argue that, in particular at SMEs who lack the necessary resources to combat such uncertainty, uncertainty and ambiguity is counterbalanced with trust in people (employees and networks) and in oneself (experience and intuition). We assume that an emotionally stable decision is made when all factors come together.

The following decision-model has been designed to guide SMEs when it comes to establishing a confident and secure position concerning internationalization.

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[1] A prior version of this paper was presented as a concept draft at the 3. International Business Management Research Conference in Chiang Mai, Thailand 2013 (cf. Dievernich, F./Schreier, C./Gong, J. (2013): SME'S Internationalization as balancing act between rationality, emotion, and intuition. In: The Journal of Business Management Research Conference VOLUME 4, DECEMBER 2013, pp. 288-310.) That draft focused on the EBD model which is presented here in a revised and more practically applicable format.
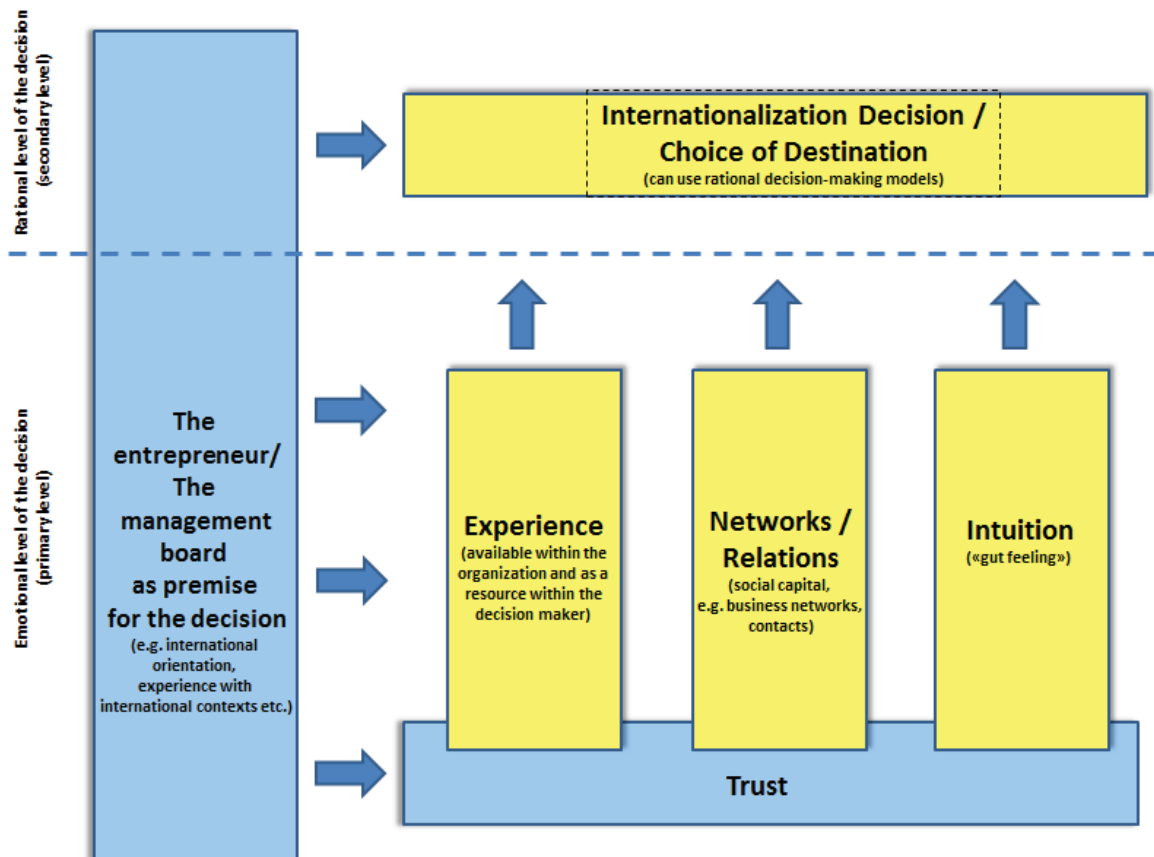
Ill. 1: The Emotion-Based Decision model (EBD) (authors' own work, 2014)

The four pillars of the EBD model: Experience, Trust, Networks, Intuition

The Emotion-Based Decision model (cf. ill. 1) focuses primarily on the person of the SME entrepreneur or the management board as the decision-making institution. This person or management board is to be understood as a decision premise and prerequisite for the entire internationalization decision. Focusing on the decision-maker, the model implies that the internationalization of an SME or the decision in favour of it depends predominantly on the personality of the decision-maker (cf. Ullrich 2011; Kanniess 2010). The internationalization practice is determined in particular by the subjective, psychologically oriented characteristics of entrepreneurs or members of the management board. "Subjective characteristics are a particularly salient source for intangible resources that differ from entrepreneur to entrepreneur and have thus a significant influence on the decision about going international" (Weber 1997, 129). The character traits of the entrepreneur, his or her values and norms, as well as basic attitudes towards internationalization contribute massively to the decision on the admission of international business. The basic attitude towards internationalization, which can be called a global mindset (the 'will'), and the intercultural abilities of the entrepreneur (the 'ability') to form the basic motivation for taking the business abroad can be called international entrepreneurial orientation (the 'doing and learning'). These are the factors that make a central contribution to the internationalization decision and to its successful outcome

(Schreier/Gong, 2013). The subjective factors named most often when discussing the internationalization of SMEs include openness, the ability to listen and communicate, performance motivation, psychological distance, courage, risk affinity, flexibility, conservatism, and the ability to look forward. In addition, the personality of the entrepreneur is characterized by prior experience with internationalization. Experienced entrepreneurs with a track record of international work are, in this sense, more likely to be innovative, flexible, and dynamic than those who act solely in the domestic market (Dichtl et al., 1983; Bamberger/Evers, 1997; Zanger/Hodicovà/Gaus, 2008; Fabian/Molina/Labianca, 2009; Gong/Schreier, 2013). Similar arguments would also apply to the small groups that make up most SMEs executive management; in this case, the internationalization decision is dependent on the traits and experiences of that group of people.

The personality of the entrepreneur therefore also includes his or her international orientation (To what extent is he or she attracted by foreign cultures or markets?), past international experience (Rated positively or negatively?), and the subjective perception of relevant foreign markets (Does he or she know certain markets and is that knowledge being seen as sufficient by the entrepreneur?). If the decision-maker has a self-perception and self-belief that is generally positively inclined towards internationalization, it seems reasonable to assume that this filter will reinforce any potential international engagement. With the entrepreneur's personality as a premise in mind, four elements that we consider relevant for the decisions of SMEs now need to be reviewed, assessed, and acted upon (or indeed not acted upon).

Trust

Trust is to be understood as an investment into a (risky) advance investment, the payoff of which is uncertain (Luhmann, 2000). The formation of trust or the potential for trust needs time, and it is generated almost automatically by investing in the pillars named above. In the end, trust is needed as a form of stored energy to be invested into an uncertain situation, in this case internationalization. At the same time, trust can only evolve in a structure that encourages an investment into an unknowable future. Trust therefore has not only an individual / psychological, but also a structural aspect: Trust is a social structural component. Trust develops only when there are structures – in this case: experience, networks, and intuition – that it can relate to (cf. first insights in Wolf/Dievernich 2014). For trust to develop, it needs a risk investment into these structures. The end result is a positive, self-reinforcing feedback loop (Dievernich, 2012). The approach leads to an increase in trust in terms of self-belief in the entrepreneur's actions in these areas and in decisions for (or against) going international (Hodicovà, 2008).

Experiences

By contrast to the personality of the decision-maker(s) as a decision-making premise – which also refers to certain elements of personal experience, experience here concerns the conscious reflection of their own experiences of internationalization and those that are available to the decision-maker(s) or the organization, which can also include the experience of other people.

This conscious reflection also covers the informal organizational experiences that can be accessed and included as another source for input for the internationalization decision (Hsu et al., 2012). What is needed in essence is a conscious decision by the entrepreneur to draw on these various experiences. Decisions about going international will become more robust the more such reflective observation – i.e. the decision-maker observing how others respond to him and his intended decisions – is allowed. Reflective observation includes an opportunity and, potentially, an invitation to adjust one's own behaviour and adapt intended decision (Grichnik/Immerthal, 2005).

Networks / Relationships

The second vertical yellow pillar of the model is formed by networks and relationships as further counterweights to the ambiguity of the internationalization decision. When one is placed in networks whose members have already taken the step abroad and for whom an international presence is par for the course, it should be possible to benefit from their experiences. This usually goes beyond experience and focuses on relevant external sources of knowledge in the foreign countries on site, who can establish contacts with possible local business partners who know the local markets at first hand (acting as brokers) or who can help with finding the right locations. The networks and relationships in this model therefore concern the participation in the available "social capital" (Kühlmann, 2005) and consciously following the lead of an established social or organizational sphere (DiMaggio, 1986) of actors with standing experience of internationalization. Opening up to networks and cooperation in this sense means a decision in favour of relationship management. These relationships then, in positive cases, lead to positive attitudes and trust concerning one's own internationalization plans in the absence of own experience (Knop, 2007; Carlsson/Dale, 2011). Internationalization is thus not only the individual achievement of a single decision-maker, but rather the engagement with external feedback and its integration in one's observations and decisions.

Intuition

Literature terms intuition a "complex pattern of human knowledge and experience" (Schmidt 2009, 2). We understand intuition as a knowledge-based inspiration, relating strongly with a certain feeling that something has to be understood in a certain way or that something has to be done or not done. It is a form of inspiration that happens before reason and reflection come into play and that conveys a certain feeling about a decision (Busse 2012, 84ff; Neubarth 2011, 62ff). Using this definition, it should become clear that a concept is being used that is fed by more than the conscious experience of the decision-maker, which makes it distinct from the first vertical pillar 'experience'. This pillar now includes the many observations that a person makes and stores over a lifetime. We can actively access these observations only if we consciously decide to take intuition seriously as a source and decide to use it deliberately. The entrepreneur should therefore explicitly leave room for his or her intuition and the intuition of the organization. Especially under conditions of limited resources, an open

dialogue within the company with decision-relevant key persons, who allow intuition its role, becomes a prerequisite for achieving a legitimate decision.

Combining all three vertical pillars, it shows clearly that prior to any decision to take of SMEs to the international stage first needs a conscious decision on the part of the entrepreneur to invest in or to deliberately engage with these pillars. Decisions about SME internationalization therefore are already taking place one step beforehand. The actual decision about internationalization, which seemed to be the first step, turns out to be a secondary step at a closer look, following and being determined by the entrepreneur's intuitive decision. Every business decision made by entrepreneurs thus grows to a greater or lesser extent from an intuitive, but subconscious construct, which we take for granted without recognizing it for what it is: a result of another decision (Grichnik/Immerthal, 2005).

It needs the – quite rational – decision to engage with other sources of experience; it needs the decision to see intuition at work and take it seriously. And it needs the decision to invest consciously into trust-based, international social capital to add to one's own experiences and abilities. All of these are pre-decisions that must to be made before the actual decision of SMEs' internationalization even comes into play.

METHODOLOGY / EMPIRICAL RESEARCH

A total of 309 Swiss SMEs took part in the mentioned empirical study conducted in November and December 2013. Of these, 128 companies responded to the full set of questions (28 questions), representing the basic sample (N) of the survey. The survey was distributed in an online format with mostly closed questions, supplemented by a small number of open-ended questions or opportunities for not pre-defined responses. It surveyed the respondent companies' current level of internationalization and internationalization intentions, their destination region/country, and the respondents' assessment of the likelihood of a successful internationalization. Furthermore, the questions explored the personal beliefs of the respondents concerning the impact of prior experiences, networks, trust, and intuition on their decisions to internationalize or the process leading to such a decision. These statements were tested for their potential correlation with the (expected) success of the internationalization venture. The decision-makers taking part in the study were also asked to assess to how they perceive their peers, i.e. decision-makers in similar positions, regarding these influences or to what extent they can see these forces acting as important variables in their peers' decision-making processes.

FINDINGS

Although there are doubtlessly many other forces influencing the internationalization of SMEs, this study considers the four factors (experience, trust, network, and intuition) supporting the basic assumption that SMEs operate with other factors in terms strategically

relevant decisions, specifically those about internationalization, than larger corporations do. This study concentrates on "personal", social influences and "competences" that are available to the individual decision-makers. The reason for this is that we can assume that decisions about internationalization ventures are made in small-scale groups or by individual people in SMEs, and not in sophisticated decision-making structures that push the individual decision-makers and their personalities into the background. For this reason, this study focuses on the effect of individual or social concepts like experience, trust, networks, and intuition on the decision to take a business abroad.

When it comes to the individual concepts, it needs to be remembered that the study did not define any specific terminology, but rather aimed at the subjective perceptions of the participants. Although we are fully cognizant of the fact that every person will have a (slightly) different notion of the term and their meanings, it is still interesting to see where the similarities and the differences in the weighting of these categories are. There seems to be a "collective consent" about the named terms or about their influence in the context of internationalization at Swiss SMEs.

It should not come as a surprise that experience is awarded relatively great influence on the success of internationalization, since the question of internationalization competences has already shown the importance of actual practice. People who act also gain experience. 63.3% of the respondents then state that experience is "highly relevant" for a successful international venture. Including the "relevant" category, there are almost 94% positive answers in this case. As stated already, networks or at least contacts with business partners would seem relevant when decisions are made. In this respect, it is not surprising that networks are attributed with a relevant or even highly relevant function in successful internationalization ventures by no less than 94.6% of the respondents.

With a score of 82.8%, trust is also awarded extremely high relevance when it comes to how much impact it has on the successful internationalization of SMEs. This seems coherent, as neither networks nor experience would seem to have much of an effect if they are not given a certain degree of trust.

The great importance of trust as a supportive competence in the internationalization processes of SMEs and as a means of giving experience its actual traction can be seen in the fact that 93.7% of the respondents rate their trust in their experience as essential. Confidence (in one's experiences), we can see, is a trait that is of major importance in international business management. This points to the enormous importance of the person of the decision-maker in terms of decision-making and business management skills. The study shows that existing intercultural experience is given a lot of weight in later internationalization efforts. Such experiences seem to be an important starting point for forming a concrete picture of the planned internationalization. In first place, almost 90% of the respondents agree that international experience and intercultural competences "help" internationalize a business.

This matches the insight that companies suffering from slow and ineffective internationalization efforts tend to blame the lack of international experience in their organizations (people), a mechanism mentioned by 60% of the participating companies. 29% also state that the reasons for failed internationalization efforts lie in such a lack of experience. The large gap between the two scores does not seem to indicate an absence of self-critical thought, but rather a sign of the importance placed on the social environment in the context of successful internationalization. This is also reflected, as we will see, in the statements concerning networks. Specifically, the study's participants see trust in essential internationalization abilities also in relation to themselves: The third most relevant trait is trust in oneself, that is, self-confidence (almost 70%). The first place is given to openness (71.8%), whereas the second most important factor is flexibility (76.6%). Coming in slightly behind self-confidence in fourth place is linguistic ability (60.2%). Self-belief indeed seems important to be able move confidently in a foreign and (therefore) potentially unsafe context. Relevant experience adds to that self-belief and thus, again, to the decision-making process.

Considering the importance of trust in terms of networks, the above picture is confirmed: 75.8% of respondents state that trust plays a central or even very central role when it comes to working in and with such networks. There is no effective networking without trust or, put differently, networking means trusting. For our topic of internationalization, we can record that networking and relationship management abilities are as relevant as the ability to trust. Trust in networks also means that competences and trust are build up in countries or markets formerly thought foreign and strange, which is highly important for any successful move abroad. The study reveals that the network of relationships is an essential resource in the context of internationalization decisions: 68.7% of SMEs say that they take all or parts of their decisions in consultation with clients and suppliers. The decisions seem to leave the (legal) boundaries of the companies they are taken in and become a matter for the entire commercial network.

Intuition is seen as relevant or even highly relevant for a successful move abroad by every second decision-maker (53.9%). Only 9.4% of the respondents consider this factor to have little practical relevance. This would make it clear that the protagonists themselves consider intuition a key means for successful internationalization in terms of making the relevant decisions at Swiss SMEs. Intuition constitutes a praeter-rational factor impacting internationalization. It is also clear that trust has to come into the equation if intuition is to be taken seriously as a source for tangible benefits. Almost half of the responds confirm that trusting intuition play a central or even very central role in every internationalization effort at SMEs. Only 12.5% of the respondents believe that trust in one's intuition plays no such role. When intuition is seen as relevant for successful internationalization, it also needs trust to become effective.

PRACTICAL IMPLICATIONS

The study's findings reveal that growth opportunities are the key external factor behind the internationalization of Swiss SMEs (87% of the participants name this reason, with cost savings following in a distant second place at 41% of respondents). In order to seize these opportunities, companies need to make optimum use of the resources and potential they have available. This also includes focusing on the factors in this study (experience, trust, networks, and intuition). Especially when compared to their larger peers who possess far more diverse resources in terms of people, finance, and strategy, it makes sense for SMEs to be looking for other means that can produce high-quality decisions 0r, at the least, shift the odds in favour of them. With this in mind, SMEs should begin to use such means systematically. The end result could be more confident decisions and a more "robust" stance, i.e. one that is supported and backed up by intuitive and emotional certainty. This would seem to be what constitutes a high-quality decision. For all of this to come true, it is, however, necessary to not look to the final decisions alone, but rather to consider the decision-making process as such. The process can be changed, whereas the effect of the eventual decision can only really be assessed with hindsight. The study also shows that there is no one-off decision as such, but rather that internationalization is a sequence of decisions and forces influencing them, which in turn create new circumstances that prescribe, if not final decisions, at least a closely defined corridor for those decisions.

In the past, many internationalization efforts of Swiss SMEs have been limited to pure export and import activities. The next level of internationalization, which includes some form of structural presence abroad, needs far greater competences than the often rudimentary ones used before. These competences need to be available for the decision-makers if they want to have the necessary security and self-confidence about the decisions they need to take.

The foundations are in place at Swiss SMEs, which is a reason for their international success to date. The decision-makers at these companies see themselves as entrepreneurs who are capable of action. Oftentimes, they are courageous enough to consciously choose a trial-and-error method. By daring to take to the international stage in the first place, they gain solid experience that enables them to carry off their acts with confidence. This is a tautological element of business life, specifically of internationalization: Experience is needed to go global – and experience is only gained by getting up and leaving one's home country. However, there are different levels of experience that can be achieve, which counters this tautological effect to some extent.

One of these levels consists of the simple acquisition of internationalization know-how (basic tools) as another means of structuring one's internationalization efforts. A dedicated look at the theory, understood as a tool of observation, helps one respond in a more sophisticated manner to the reality one is confronted with. What is needed in the end, as our study suggests, is the conscious exploration and application of competences and resources that used to be

used only sporadically and without purpose. This includes a conscious engagement with the question of personality as a source of trust in the decision-maker's actions, a recapitulation and assessment of available experience, the focused work on one's networks, and the effective use of intuition as an additional source of "knowledge". All four combined lead to emotionally confident decisions. Trusting these components is relevant for the next steps on the international journey. The rather minor presence of cooperation formats (joint ventures: 17.7%), for instance, might be taken as a sign that Swiss SMEs would do well to continue investing into such "soft" competences.

As long as human beings and their personalities hold sway as decision-makers in SMEs, in the sense of being available and not replaced completely by anonymous structures, using these conditions that are unique to SMEs can offer much potential for success in terms of their internationalization decisions. In short: SMEs should not try to simply emulate their larger peers in the economy.

SMEs retain their unique strategic advantage by coming aware of and using their characteristic strengths. Strengths need to be strengthened for them to become what they already are in essence.

ORIGINALITY / CONTRIBUTION AND LOOK-AHEAD

Our research intends to contribute to (re-)establishing factors that a rationalist view of economics, organizations, and decision-making would consider irrational as viable rational arguments. The insights outlined here and already validated empirically need to be integrated into the theory of intangible assets, assets that have a major impact on the competitiveness of companies (cf. Barney 1991). Focusing consciously on the individual and social factors in theory and practice can help SMEs establish a unique intangible asset that goes far beyond the availability of traditional resource assets and that other companies will find hard to emulate. Future research needs to focus on exploring that category of assets proposed here in theory and practice and on finding ways to integrate it into business practice. In the end, the individual effect of each factor on the quality of a decision-making process and on individual internationalization decisions still needs to be understood. It should also be pointed out that this research forms but a small part of the development of a management toolkit unique to SMEs, in particular for ways to deal with ambiguous decision that differ from those commonly used in large corporate structures. Intuition tells us that we should continue our exploration.

REFERENCES

1. Baldegger, R. (2013). Swiss International Entrepreneurship Survey 2013. Studienergebnisse zum Internationalisierungsverhalten von Schweizer KMU. Freiburg/Bern.

2. Baldegger, R. et al (2010). Studie zum Internationalisierungsverhalten von Schweizer Unternehmen. Swiss International Entrepreneurship Survey 2010. Freiburg/Bern.
3. Bamberger, I.; Evers, M. (1997). Ursachen und Verläufe von Internationalisierungs-entscheidungen mittelständischer Unternehmen. In: Macharzina, K.; Oesterle, M.-J. (Ed.): Handbuch Internationales Management. Wiesbaden, pp. 103-133.
4. Barney, J. (1991). Firm resources and sustained competitive advantage. In: Journal of Management, 17(1): 99–120.
5. Busse, D. (2012). Nachhaltigkeitsaspekte in Theorie und Praxis der Entscheidungs-findung, Wiesbaden: Gabler.
6. Capoccia, G./Kelemen, R.D. (2007). The study of critical junctures. In: World Politics 59, pp. 341-369.
7. Carlsson, E.; Dale, B. (2011). Internationalization of knowledge-intensive SMEs: The case of petroleum-related suppliers. In: Norwegian Journal of Geography, 65:4, pp. 191-201.
8. Casson, M.C./Buckley, P.J. (2009). The Multinational Enterprise Revisited: The Essential Buckley and Casson. Basingstoke, Hants: Palgrave Macmillan.
9. Collier, R.B./Collier, D. (1991). Shaping the political arena: critical junctures, the labor movement, and regime dynamics in Latin America. Princeton University Press.
10. Credit Suisse (2010). Megatrends – Chancen und Risiken für KMU. Studie 2010: Schwerpunkt Globalisierung, Zürich.
11. Crick, D./Spence, M. (2005). The internationalisation of 'high performing' UK high-tech SMEs: a study of planned and unplanned strategies. In: International Business Review, 14, pp. 167–185.
12. Dichtl, E. et al. (1983). Die Entscheidung kleinerer und mittlerer Unternehmen für die Aufnahme einer Exporttätigkeit. In: ZfB, Year 53, Issue 5, pp. 428-443.
13. Dievernich, F. (2012). Pfadabhängigkeitstheoretische Beiträge zur Zukunftsgestaltung. In: V. Tiberius (Ed.): Zukunftsgenese. Theorien des zukünftigen Wandels. Berlin: Springer VS.
14. Dievernich, F./Schreier, C./Gong, J. (2013). Das emotional basierte Entscheidungsmodell. In: KMU-Magazin 12/2013, pp. 88-93.
15. DiMaggio, P.J. (1986). Structural analysis of organizational fields. In: R.H. Hall/R.E. Quinn (Eds.): Organizational Theory and Public Policy. Beverly Hills.
16. EIM Business & Policy Research (2011). Opportunities for the internationalisation of European SMEs, Brussels.
17. EIM Business & Policy Research (2010). Internationalisation of European SMEs, Brussels.
18. European Network for SME Research (2003). Beobachtungsnetz der europäischen KMU. Internationalisierung von KMU, Nr.4, Luxembourg.
19. Fabian, F./Molina, H./Labianca G. (2009). Understanding Decisions to Internationalize by Small and Medium-sized Firms Located in an Emerging Market. In: Management Inter-national Review, 49: pp. 537-563.

20. Glückler, J. (2006). A relational assessment of international market entry in management consulting. In: Journal of Economic Geography 6, pp. 369-393.

21. Gong, J./Schreier, C. (2013). Wie KMU-Chefs den Internationalisierungsprozess angehen. In: Blickpunkt KMU, Nr. 5.

22. Grichnik, D./Immerthal, L. (2005). Rationalität und Risiko der Gründungsentscheidung. In: DBW 65, pp. 563-583.

23. Hodicovà, R. (2008). Psychische Distanz und Internationalisierung von KMU – Empirische Untersuchung am Beispiel des sächsisch-tschechischen Grenzraums, Wiesbaden: Deutscher Universitäts-Verlag.

24. Holtbrügge, D. (2005). Lerntheorie der Internationalisierung von Johanson/Vahlne: Grundzüge, empirische Relevanz und Kritik. Working Paper 3/2005, Nuremberg.

25. Hsu, W./Chen, H./Cheng, C. (2012). Internationalization and firm performance of SMEs: The moderating effects of CEO attributes. In: Journal of World Business, 48: pp. 1-12.

26. IHK Bochum (2010). Internationalisierungsstrategien des Mittelstands. Bochum.

27. Kanniess, M. (2010). Key factors for successful internationalization of SME's in Transitioin Economies in South Eastern Europe in the Light of Global Recessioin. In: Fifth International Conference of the School of Economics and Business in Sarajevo (ICES).

28. Knop, R. (2009). Erfolgsfaktoren strategischer Netzwerke kleiner und mittlerer Unternehmen. Wiesbaden: Gabler.

29. Kühlmann, T. (2005). Internationalisierung im Netzwerk. Der Mittelstand entdeckt das Sozialkapital. Retrieved March 12, 2013, from Web site: www.forost.lmu.de...lit_proj4_Kuehlmann

30. Luhmann, N. (2000). Vertrauen. Ein Mechanismus zur Reduktion sozialer Komplexität. UTB.

31. Neubarth, A. (2011). Führungskompetenz aufbauen, Wiesbaden: Gabler Verlag.

32. OECD (2004). Facilitating SMEs Access to International Markets, OECD Global Conference, 3-5 June 2004, Istanbul, Türkei.

33. Schmidt, M. (2009). Management – Handlungsmuster erfolgreicher Führungskräfte. Wiesbaden: Gabler.

34. Schreier/Dievernich/Gong (2013). SME internationalization: the interculturally intelligent decision maker between rationality and intuition. Conference paper, 70th International Business Management Conference, Silpakorn University, Bangkok, Thailand.

35. Schreier, C./Gong, J. (2013). Die Unternehmerpersönlichkeit entscheidet über den Erfolg. In: KMU-Magazin, Nr. 3.

36. Schreyögg, G./Sydow, J./Koch, J. (2003). Organisatorische Pfade. In: G. Schreyögg/J. Sydow (Hrsg.): Managementforschung 13. Wiesbaden: Gabler Verlag.

37. Switzerland Global Enterprise (2012). http://annualreport2012.s-ge.com/welcome/interview.html.

38. Ullrich, S. (2011). Internetbasierte Internationalisierung. Entscheidungsfindung, Umsetzung und Erfolgsmessung. Wiesbaden: Gabler Verlag.

39. Weber, P. (1997). Internationalisierungsstrategien mittelständischer Unternehmen. Wiesbaden.

40. Wolf, P./Dievernich, F. (2014). Trust me if you can. Paper-Presentation at the EGOS-Conference, Rotterdam, 2014.

41. Zanger, C./Hodicovà, R./Gaus, H. (2008). Psychic distance and cross – border cooperation of SMEs: An empirical study on Saxon and Czech entrepreneurs' interest in cooperation. In: JEEMS, 1.

BRAND MARKETING STRATEGY IN TAIWANESE CLOTHING AND TEXTILE MARKET

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ABSTRACT

In today's market economy, which is characterized by a very changeable environment and strong, intense competition because mainly by enlarging globalization, it is becoming more and more difficult for an enterprise in maintain long-term success. Due to Taiwan join WTO and ECFA (Economic Cooperation Framework Agreement), textile goods faced global competition. With the short life cycle of the textile market and demand uncertainty in market, it leads to increasing pressure on the clothing and textile industry. That is why the significance and meaning of brands have been growing recently. 7 Senior managers, from three Taiwanese textile and clothing companies, were interviewed about their understanding and use of brand strategies in their marketing performance. The aim of this study is to show that a properly applied brand strategy is the enterprise's most valuable asset, and should be the most important task for the company. The finding proposes that Taiwanese clothing and textile companies need to develop a new business model which integrated all the processes including design, procurement, production, and marketing. Considering Taiwan domestic demand market is too small and brand awareness is not strong, this study suggests that the clothing and textile industry should make emphasis on the international market and identify accurate brand positioning. Moreover, human capacity building is an important issue that companies should have a long-term program and direction for their brand development.

Keywords：Brand, brand strategy, brand awareness, brand positioning, clothing and textile industry

INTRODUCTION

Fabric was the main export item for Taiwan, took up 61.3% of total textile exports, and the major five export markets accounted for 59.5% of total textile exports (TIF, 2012) including mainland China, Vietnam, Hong Kong, United States and Indonesia. According to the data from Taiwan Department of Statistic (2012), the gross export and import values of Taiwan textile production were US $11.82 billion and US $3.32 billion. In that same year, Taiwan Fabric Federation (TTF, 2012) declared that the textile industry recorded a total trade surplus of US $8.50 billion, which marking it Taiwan's fourth-largest trade surplus industry. The two of these markets, mainland China and Hong Kong, accounted for 31.4% of total exports, amounting to US $3.71 billion. Therefore, the textile industry of Taiwan is highly export-oriented.

Current Trend in the World Textile Market

Two trends in the clothing and furnishing appliances markets have emerged. One is functional textile, which is highly regarded by consumer for fashion, ergonomic, comfort, safety and health reasons. The other is eco-textile with the characteristics of low pollution, low energy consumption, recyclable, and minimal negative impact on the environment. Taiwan textile industry is therefore vigorously considering incorporating these environmental factors in its development of functional textile. Great opportunities do exist for Taiwan textile industry as it strives to accommodate the two newly emerging market trends, namely functionality and environmental consciousness.

Global economy is confronted with uncertainty after 2008 financial tsunami. The economics recovery of USA is in slow pace. EU still struggles with debt crisis. Japan takes currency depreciation to save its economy, but brings the risk of currency dispute among Asia countries. Taiwan is also exposed to this crisis. The textile industry is faced with fierce competition in an oversupply condition since emerging countries have joined the development of textile industry. The issues of energy saving and carbon reduction become the primary concern while global warming and climate change becomes extremely anomalous. Human right, environmental protection, sustainability and corporate social responsibility are long-term trends of major brands and buyers, and affect business strategy of suppliers.

However, to cope with the severe competition and adverse business environment, Taiwan textile industry needs to come up with the brand strategies, for example, to create high value-added materials and produces to enhance product differentiation in the clothing and textile market. It enables to segment Taiwan product from that of other developing countries. If doing so, it not only raises the image of Taiwan textile products, but also widens the lead over other developing countries.

Most previous studies about the clothing and textile market were conducted in the United States or other Western countries, so their findings may not be generalizable to market without empirical testing. This study, in contrast, in order to address the aforementioned deficiencies in the literature, this study will understand the current situation and problem which Taiwan clothing and textile industry has faced. It will also explore the brand strategy which has applied by the clothing and textile industry in Taiwan. This research examines the different effects of detailed marketing practices on brand management building in the Taiwan clothing and textile market.

LITERATURE REVIEW

The constantly changing market poses new challenges to clothing enterprises, and the clients' demands are also continually rising, and so it is necessary every now and again to offer them a higher added value. This added value is a properly planned brand strategy, the so-called branding. Firms without any distinct features, without a clear vision or specific mission, or without permanent values, will sink in the mass of messages hitting the market.

A brand image is defined through its selected symbolic patterns (Agres and Dubitsky, 1996). Most important among these are the brand's name, logo, and composition of graphic elements and colors all associated with the company (Dean, 1999). It is crucial for a brand built on these elements to give a clear message to the customer about the kind of company and dealing with, what its product is and who the clients are. All the elements comprising a brand image have to be closely related to the idea and goals of the company (Calderon, et al., 1997; Byrne, 2003). This certainly helps its positive identification, and as a result a strong and distinct image is created in the customers' mind (Sangkhawasi and Johri, 2007). It is important that the customer's mind should absorb and retain as much information about a brand as possible; some time later this is translated into the reconcilability and prestige of a brand on the market. A brand product offers a sense of safety, and guarantees quality and reliability. Brand values are features that appeal to the emotional sphere of human perception (Buzzell, and Wiersema, 1981).

Hence a brand is the most valuable asset of a company, and customer satisfaction is the key to a long-term success. As consumers must have a reason for selecting this given brand from among many others, each brand should have a motto apart from its distinctive usability. It is necessary to define why it is different and what its position is. A brand is not an advertisement, but rather a whole philosophy underlying a set of combined actions fixed on the company's success (Cobb-Walgren, *et al.*, 1995; Byrne, 2003). It is certainly an indispensable tool allowing effective conquest of markets, retention of the market position, and international competition

In addition, global marketing strategy poses unique challenges and opportunities for managers, especially in branding and product development. A key outcome of global positioning strategy is

the development of a global brand. Well-known global brands such as H&M, ZARA, and UNIQLO have change the consumers purchasing behaviors which consumers can spend less but gain fashion. Consumers prefer these globally branded products because branding provides a sense of trust and confidence in their purchasing (Cavusgil, *et al*., 2014). These most successful global brands tend to have several characteristics including high and conspicuous visibility, innovative features, and close identification (Cavusgil, *et al*., 2014). However, Taiwan clothing and textile industry has placed too much emphasis on OEM, but not developing the innovation technology and human resources. Taiwanese brands such as Tony Wear, AMASS, and Take-IT lacks high visibility and identification because these brands need to develop the global recognition. Therefore, a strong global brand should be supported by enhances the efficiency and effectiveness of marketing programs.

DATA COLLECTION AND ANALYSIS

In order to choose the most appropriate methodology to be applied in this research paper, relevant literature and internet sources of information were consulted. Qualitative, in-depth interviews were used to address the research questions. Data collection took place between August 2012 and April 2013. 9 textile companies were contacted by phone and email and asked to participate in this research. 3 companies agreed to take part and 7 in-depth interviews were conducted. All managers interviewed claimed to have knowledge of their brand strategies, and typically occupied posts such as Senior Marketing Manager. All interviews were taped, transcribed and analyzed using thematic coding.

FINDING

The Importance of Intellectual Property Rights
Although Taiwan's textile has become one of world's biggest suppliers of functional textiles, however, Taiwan government didn't place enough attention on the problem of the intellectual property right. In other words, just bring a piece of cloth or clothing to Taiwan, it can be found or produced exactly the same on in short time. Most managers declare that human capacity building is an important issue that companies should have a long-term program and direction for their brand development. The intellectual property rights protection should be implemented immediately. This study also suggests that textile and clothing companies should increase the investment of development of human capacity.

Global Branding for International Market
Most Textile and clothing companies are small and medium enterprises (SMEs) in Taiwan. The findings show that these mangers think global branding helps the SMEs compete more effectively to enter international market. Moreover, the finding proposes that Taiwanese clothing

and textile companies need to develop a new business model which integrated all the processes including design, procurement, production, and marketing. Considering Taiwan domestic demand market is too small and brand awareness is not strong, this study suggests that the clothing and textile industry should make emphasis on the international market and identify accurate brand positioning.

Although lots Taiwan textile and clothing companies declare they can be international or innovative, but actually only a small group is highly internationalized and have superior innovations, specifically those that invest abroad and spend more resources to innovate. In addition, regional economy is on the rise. In the past, Taiwan clothing and textile industry places too much emphasis on the low cost textiles. However, the quantity pricing strategy may no longer the international trend. In order to survive in this global competitive market, Taiwan textile industry has to reform. Not just manufacturing, also applying marketing on international brand which makes Taiwan different from other emerging countries.

REFERENCES

1. **Aaker, D.A.** (1991), Managing Brand Equity – Capitalizing on the Value of a Brand Name, The Free Press, New York
2. **Agres, S.J. and Dubitsky, T.M.** (1996), Changing needs for brand, *Journal of Advertising Research*, 36(1), 21-30
3. **Bruder, S.M., Cassil, N., and Jones, M.** (2005), Branding to Compete: Applications to Textiles and Apparel, *Journal of Textiles and Apparel*, 4(3)
4. **Buzzell, R.D., and Wiersema, F.D.** (1981), Successful share building strategies, *Harvard Business Review*, 59(1), 135-144
5. **Byrne, K** (2003), Creating Brand Equity, *Chartered Accountants Journal of New Zealand*, 82(10), 61-65
6. **Cavusgil, S., Knight, G., and Riesenberger, J.** (2014), International Business: The Ne w Realities, 3nd Edition, PEARSON
7. **Calderon, H., Cervera, A., Molla, A.** (1997), Brand assessment: a key element of marketing strategy, *Journal of Product & Brand Management*, 6(5), 293-304
8. **Cobb-Walgren, Beal, C.J., and Donthu, N.** (1995), Brand equity, Brand preferences, and purchase intent, *Journal of Advertising*, 24(2), 25-40
9. **Dean, D.H.** (1999), Brand endorsement, popularity, and event sponsorship as advertising cues affecting consumer pre-purchase attitudes, *Journal of Advertising*, 28(3), 1-13
10. **Sangkhawasi, T., and Johri, L.M** (2007), Impact of status brand strategy on materialism in Thailand, *Journal of Consumer Marketing*, 24(5), 275-282
11. **Taiwan Textile Federation** (2013), Overview of Taiwan Textile Industry-2012, available at: ttf.textiles.org.tw/Textile/TTFroot/overview-english.pdf (accessed on 2 February 2014).

HOW DO SUPPLIERS DRIVE BUYER-SUPPLIER KNOWLEDGE SHARING?

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ABSTRACT

Purpose: Supplier behaviors are considered to influence buyer-supplier cooperation, including bilateral knowledge sharing. However, previous research does not explain the mechanism through which this influence occurs. This study proposes a research model based on the relational exchange theory to explain the mechanism by which current and alternative suppliers impact buyer-supplier knowledge sharing.

Design/methodology/approach: The empirical data was collected from the research and development staff of Taiwanese electronics firms. The structural equation modeling was used to test and verify the appropriateness of the hypothetical model.

Findings: The empirical findings show that the current supplier asset specificity positively influences, directly and indirectly, the buyer-supplier knowledge sharing in new product development via the mediating effects of buyer perceived trust and satisfaction and the relevant buyer commitment. On the other hand, the alternative attractiveness only indirectly and negatively affects buyer-supplier knowledge sharing via the mediating effects of trust, satisfaction, and commitment. Evidently, the influences of asset specificity exceed those of the alternative attractiveness.

Research limitations/implication: Future research could investigate other countries and industries to generalize the proposed model and research findings. The non-response bias examination should be considered in advance in methodology.

Practical implications: The findings imply that current suppliers should focus to ensure and satisfy buyers' specific asset demand other than concern competing suppliers' alternative

attractiveness.

Originality/value: This paper is the first study investigating knowledge sharing antecedents via the approach of both influences from current and alternative suppliers, and adopts relational exchange theory in explaining its influence mechanism.

Keywords: Asset specificity, Trust, Satisfaction, Commitment, Knowledge sharing, New product development

Paper type: Research paper

INTRODUCTION

Inter-organizational knowledge sharing becomes a common practice for the enhancement of supply chain competitive advantage (Cheng *et al.*, 2008). Knowledge sharing enhances the ability of manufacturers to learn from their local partners (Nonaka, 1994) and provide additional knowledge for buyer product development. However, customers may hesitate to reciprocate knowledge for fear of leaking confidential information to competitors, and also out of fear that the supplier may become a competitor as well. Thus, the factors influencing buyer-supplier knowledge sharing in product development, deserve further study.

The availability and attractiveness of alternatives is another perspective to examine for buyer-supplier relationships (Bendapudi and Berry, 1997). Alternative attractiveness is crucial to buyer perceived relationship quality (Ohanian, 1990), and then influences current buyer-supplier cooperation, including knowledge sharing. Current supplier asset specificity and competing supplier attractiveness are thus the very key factors influencing knowledge sharing. Nevertheless, extant research has not explored how asset specificity and alternative attractiveness affect buyer-supplier knowledge sharing.

The goal of this study is to clarify the mechanism by which supplier asset specificity and alternative attractiveness influence buyer-supplier knowledge sharing in buyer new product development. The contribution of this study lies in it being the first to investigate knowledge sharing antecedents from the perspective of both influences of current and alternative suppliers.

HYPOTHESES DEVELOPMENT

Relational exchange theory (RET) postulates relational norms as a distinct form of governance (the relational governance) that prescribes commitment and proscribes opportunism in exchange relationships (Morgan and Hunt, 1994). Williamson (1991) defined asset specificity as the degree to which an asset can be redeployed for alternative uses by alternative users, without sacrificing productive value.

Suppliers willing to invest in specific assets for customers are more likely to fulfill customer demands, and thus achieve higher customer satisfaction. Skarmeas and Robson (2008) examined the relationship between exporters and importers and demonstrated that exporter specific investments can increase importer satisfaction with the overall international exchange relationship. Based on the above discussion, this study hypothesizes the following:

H1.   Supplier asset specificity positively influences buyer satisfaction.

The specific asset investments of both parties strongly influence firm trust in supply chain partners (Kwon and Suh, 2005). Likewise, Lui *et al.* (2009) found that asset specificity relates positively to trust in a procurement relationship. Based on the above studies, this study hypothesizes the following:

H2.   Supplier asset specificity positively influences buyer trust.

The good performance of alternatives has been shown to reduce customer satisfaction with the current choices available (Inman *et al.*, 1997; Taylor, 1997). Regardless of whether a firm is originally satisfied or unsatisfied with its current supplier, that firm might experience regret at failing to deal with that alternative supplier, and its satisfaction will be reduced once it is aware of and recognizes the existence of a superior supplier. This study thus hypothesizes the following:

H3.   Alternative attractiveness negatively influences buyer satisfaction.

Wakefield *et al.* (2004) justified the existence of a positive relationship between web site attractiveness and initial trust in a web site. The related studies above, however, only focus on the positive relationship between one party's attractiveness and the other party's trust. If there is a third party, who is more attractive than the first party, the second party's trust towards the first party would be practically reduced. This study thus hypothesizes the following:

H4. Alternative attractiveness negatively influences buyer trust.

Nusair *et al.* (2010) developed a model based on the existing literature, showing that satisfaction and trust are antecedents of commitment. Van Riel *et al.* (2011) posited that satisfaction with the main supplier positively affects dealer commitment to that supplier. Consequently, this study hypothesizes the following:

H5. Buyer satisfaction positively influences buyer commitment.

Kuhlmeier and Knight (2010) found that in the relationship between the exporting SME and its foreign intermediaries, trust is positively and significantly associated with commitment. Trust is a significant antecedent of commitment. Van Riel *et al.* (2011) found that trust in the main supplier positively affects dealer commitment to that supplier. Based on the above, this study hypothesizes the following:

H6. Buyer trust positively influences buyer commitment.

Storey and Quintas (2001) argued that developing knowledge worker commitment is critical, because this results in knowledge retention through greater willingness to share knowledge. Thompson and Heron (2006) found that commitment is positively related to knowledge-sharing. This study thus hypothesizes the following:

H7. Buyer commitment positively influences buyer-supplier knowledge sharing in buyer new product development.

Luo *et al.* (2009) proposed that relationship-specific investment generates successful buyer-supplier partnerships via the mediation effect of knowledge sharing. Furthermore, Herna´ndez-Espallardo *et al.* (2010) found that supplier investments in relationship specific assets increase customer investments in knowledge-sharing routines in supply chains. Accordingly, this study hypothesizes the following:

H8. Supplier asset specificity positively influences buyer-supplier knowledge sharing in buyer new product development.

METHODOLOGY

This study developed and applied constructional measures adapted from the extant literature The final version of the questionnaire was obtained by identifying a satisfactory level of internal consistency for each construct. Respondents were asked to grade all items using a five-point Likert-scale (1 = "strongly disagree", up to 5 = "strongly agree"). Taiwanese electronic firms were selected for the survey because they are leaders in electronic product manufacturing and are influential in the capital and knowledge intensive electronics industry. The study sample firms were comprised of electronics firms listed in the Taiwan Stock Exchange Market. The data collection process then focused on the responses of the staff of the sample firms.

To improve the questionnaire response rate, the authors first telephoned the sample firms and asked for the e-mail addresses of the targeted respondents to distribute questionnaires via e-mail. Hard copy questionnaires were then mailed to the firms that did not provide e-mail address information. In total, this study distributed 1,475 questionnaires to the sample firms via mail and e-mail. A total of 246 eligible questionnaires were received, representing an effective response rate of 16.7%.

DATA ANALYSIS AND RESULTS

The hypothesized relationships are examined using the structural equation modeling (SEM) approach. The ratio of chi square (516.97) over the degrees of freedom (243) is close to the 2.00 threshold and indicates that the proposed research model is a good fit. Some other indices are used to examine the model fit. The comparative fit index (CFI) and incremental fit index (IFI) are both 0.97, exceeding the 0.90 threshold and indicating good model fit. The non-normed fit index (NNFI) is 0.97, implying good fit. The root mean square error of approximation (RMSEA) is 0.068, also indicating good model fit. Through the above goodness-of-fit indices, this study achieves acceptable model fit. The hypotheses H3-H4 is supported at the $p<0.01$ significance level. H1-H2 and H5-H8 are supported at the $p<0.001$ significance level.

MANAGERIAL IMPLICATIONS, RESEARCH LIMITATIONS AND SUGGESTIONS

This study finds that the positive forces of asset specificity from current suppliers exceed the negative forces of alternative attractiveness from competing suppliers. Therefore, the main concern of current suppliers is to ensure that they can satisfy buyer demand of asset

specificity. Current suppliers should invest in tailor-made products, equipment, or even factories to address buyer specific demands. Extensive time and human resources can help strengthen long-term buyer-supplier relationships and buyer commitment, thus enabling sufficient buyer-supplier knowledge sharing in buyer new product development.

The limitation of this study is that the sample frame is limited to the Taiwanese electronics industry. Electronics firms from other countries are also leaders in global, high technology markets. Future research thus could extend to other countries, such as America and Japan. Meanwhile, numerous industries, including traditional industries, also conduct product development activities. Future research thus can reexamine proposed models in other industries.

REFERENCES

1. Bendapudi, N. and Berry, L.L. (1997), "Customers' motivations for maintaining relationships with service providers", *Journal of Retailing*, Vol. 71 No. 3, pp. 223-47.
2. Cheng, J.H., Yeh, C.H. and Tu, C.W. (2008), "Trust and knowledge sharing in green supply chains", *Supply Chain Management: An International Journal*, Vol. 11 No. 4, pp. 283-95.
3. Herna´ndez-Espallardo, M., Rodriguez-Orejuela, A. and Sa´nchez-Pe´rez, M. (2010), "Inter- organizational governance, learning and performance in supply chains", *Supply Chain Management: An International Journal*, Vol. 15 No. 2, pp. 101-14.
4. Inman, J.J., Dyer, J.S. and Jia, J. (1997), "A generalized utility model of disappointment and regret effects on post-choice valuation", *Marketing Science*, Vol. 16 No. 2, pp. 97–111.
5. Kuhlmeier, D.B. and Knight, G. (2010), "The critical role of relationship quality in small- and medium-sized enterprise internationalization", *Journal of Global Marketing*, Vol. 23 No. 1, pp. 16-32.
6. Kwon, I.G. and Suh, T. (2005), "Trust, commitment and relationships in supply chain management: a path analysis", *Supply Chain Management*, Vol. 10 No. 1, pp. 26-33.
7. Lui, S.S., Wong, Y.Y. and Liu, W. (2009), "Asset specificity roles in interfirm cooperation: reducing opportunistic behavior or increasing cooperative behavior?", *Journal of Business Research*, Vol. 62 No. 11, pp. 1214-9.
8. Luo, Y., Liu, Y. and Xue, J. (2009), "Relationship investment and channel performance: an analysis of mediating forces", *Journal of Management Studies*, Vol. 46 No. 7, pp. 1113-37.

9. Morgan, R. and Hunt, S. (1994), "The commitment-trust theory of relationship marketing", *Journal of Marketing*, Vol. 58 No. 3, pp. 20-38.

10. Nonaka, I. (1994), "A dynamic theory of organizational knowledge creation", *Organization Science*, Vol. 5 No. 1, pp. 14-37.

11. Nusair, K.K., Hua, N. and Li, X. (2010), "A conceptual framework of relationship commitment: e-travel agencies", *Journal of Hospitality and Tourism Technology*, Vol. 1 No. 2, pp. 106-20.

12. Ohanian, R. (1990), "Construction and validation of a scale to measure celebrity endorsers' perceived expertise, tmstworthiness, and attractiveness", *Journal of Advertising*, Vol. 19 No. 3, pp. 39-52.

13. Skarmeas, D. and Robson, M.J. (2008), "Determinants of relationship quality in importer-exporter relationships", *British Journal of Management*, Vol. 19 No. 2, pp. 171-84.

14. Storey, J. and Quintas, P. (2001), "Knowledge management and HRM", in Storey, J. (Eds.), *Hutnan Resource Managemetit: A Critical Text*, Thomson Leamin, London.

15. Taylor, K.A. (1997), "A regret theory approach to assessing consumer satisfaction", *Marketing Letters*, Vol. 8 No. 2, pp. 229-38.

16. Thompson, M. and Heron, P. (2006), "Relational quality and innovative performance in R&D based science and technology firms", *Human Resource Management Journal*, Vol. 16 No. 1, pp. 28-47.

17. Van Riel, A.C.R., Liljander, V., Semeijn, J. and Polsa, P. (2011), "EU deregulation and dealer-supplier relations in automotive distribution", *Journal of Business & Industrial Marketing*, Vol. 26 No. 2, pp. 115-31.

18. Wakefield, R.L., Stocks, M.H. and Wilder, W.M. (2004), "The role of web site characteristics in initial trust formation", *The Journal of Computer Information Systems*, Vol. 45 No. 1, pp. 94-103.

19. Williamson, O.E. (1991), "Strategizing, economizing, and economic organization", *Strategic Management Journal*, Vol. 12, pp. 75-94.

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MATURITY MODELS AS A SOURCE FOR RELENTLESS DRIVE TOWARDS OPERATIONAL EXCELLENCE

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ABSTRACT

Purpose: The challenge of every company is to beat competition and grow, and when successful then remain competitive. Maturity models are examined in this research as a source for relentless drive towards operational excellence. These models are used inside companies to build momentum for change, continuous improvement and roadmap of building world class operations. Case company ABB Corporation is presented as example for applying maturity models to fuel the quest for operational excellence.

Design/methodology/approach: This study is based on the literature findings on maturity models concepts, analyses of their characteristics, and a presentation of the case company.

Findings: The literature findings are presented as a summary of the maturity models background and fundamentals, the case company application of maturity models is examined and evaluated.

Research limitations/implications: This paper is based on literature findings and related analyses as well as a case company presentation and evaluation. Future research should expand the discussions to other case companies.

Practical implications: The maturity models application at a case company provides valuable reference with practical discussion to any company looking for framework to remain competitive and drive operational excellence agenda.

Originality/value: Maturity approaches have their roots in the field of quality management. One of the earliest of the maturity models is from 1979 Crosby's Quality Management Maturity Grid (QMMG). The maturity models concepts have been since been expanding to various areas and standards. The large scale application of several maturity models to various corporate functions within same overall umbrella presented in the case company provides unique contribution to the maturity models application in driving operational excellence.

Keywords: Maturity models, operational excellence, ABB Corporation, self-assessments

Article classification: Research paper

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DESIGNING PARTICIPATORY EDUCATIONAL APPLICATION USING NFC

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ABSTRACT

Purpose: The awareness of importance on history and culture education has increasing steadily. However there are only a few e-learning contents which meet needs of users. Therefore this paper suggests a new concept of system, history and culture education application, satisfying those demands. This proposed system designed to make users learn history and culture more easily and naturally as well as encourage users' voluntary participation by taking a function of Near Field Communication(NFC) and asking users to tag directly on NFC tag.

Design/methodology/approach: The paper has analyzed other studies and use-cases to deign well-structured system and standardize consistent contents for educational efficiency. The interviews and surveys also conducted to prove whether the system design and standardized contents assure usability or meet user's needs.

Findings: The Preferences for the e-learning service based on the game are the growing trend for user's active participation. And the answers from the survey proved that "the stamp tour" could be a mean of educational application specialized in history and culture. For the design side, small tests after each session[1], 4~5 of contents in a session view [2], and the standardized list of the contents consisted of Official Title, Cultural Value, and Historical Background[3] are highly recommended.

Originality/value: Based on the results of the survey, the paper designs system architecture corresponded to the market conditions and all the needs of users. In addition, this application uses NFC technology, has not been used previously for educational purpose, in order to enhance the user's participation. The standardization of the contents also provided to improve the usability for users and the ease of management for provider.

Keywords: Educational Application, E-Learning, Smart-Learning, G-Learning, NFC (Near Field Communication), Stamp Tour

INTRODUCTION

The rapid development of Information Technology causes the positive changes for educational environment and builds the new forms of learning paradigm. E-Learning could be one of the results of these changes. There are many types of e-learning methods. And through appearance of diverse smart devices, smart learning(s-learning) and game learning (g-learning) have been the growing trends. They have many benefits not only the unconstraint on time and place, so users could escape from the stuffy classroom and study anytime they want, but also the user-friendly service which maximizes the mobility and convenience with the smart devices. However, because of biased contents toward foreign languages (57. 62%, result from the survey), 70.2% of the s-learning users choose diversification of the contents and 19.7% of them choose volition of themselves as the problem to be solved (Son M. J., 2012). In addition, history and culture are the major subjects in most of the countries and practically they are the topics on demand (Lim J. T. and Suh K. S., 2011). However from the results of the analysis of use-cases, there are only 4.66% of educational applications for history and culture.

To solve these problems, lack of the s-learning contents which meet needs of users, and to realize ideal educational environment, this paper suggests the participatory educational android application adopting the stamp tour service for attracting users and using NFC technology which requires short recognition distance so users has to go and experience historical site easily and naturally. Also suggests the legibility view of system architecture for effective communication by standardizing the list of the contents to be displayed on users' smart device view.

THEORETICAL BACKGROUND

The Current Condition of Applications and Contents for History and Culture
Existing Mobile Applications of History and Culture

Recently there have been extreme increases on smartphone users not only in Korea but in globally (International Data Corporation, 2014). At the same time, the demand and supply for new and interesting application also have been increasing rapidly (Portio Research, 2014). Especially because of increasing importance on history recognition and topicality of social

phenomenon from coexistence of diverse cultures from around world, demand for history and culture application is also increasing steadily (*Kim K. S., 2014*). Followings are the different types of applications focused on History and culture.

Table I. Different Types of Applications Focused on History and Culture.

Application Name	Category	Feature	Source
History Books	Books and Resources	The Simple one-way information delivery format in text	History Books (2014)
Silla History Tour	Travel and Local information	The lists of related pictures and drawings with storytelling type of audio	Silla History Tour (2014)
Bekje History Tour	Travel and Local information	The lists of related pictures and drawings with storytelling type of audio	Bekje History Tour (2014)
History Quiz Expedition	Education	The quiz game format	History Quiz Expedition (2014)
Daehak-ro performance information	Entertainment	The lists of cultural performance information and the location map of related places.	Daehak-ro performance information (2014)
Art Day	Lifestyle	The lists of exhibition information and the location map of related places.	Art Day (2013)
My Exploration of cultural heritage	Travel and Local information	The G-learning format.	My Exploration of cultural heritage (2013)
Korean History Timeline	Education	The Simple one-way information delivery format in text	Korean History Timeline (2014)
I am Korean	Communication	The lists of URL containing related videos and information	I am Korean(2013)
History Calendar	Entertainment	The simple one-way information delivery format in text	History Calendar (2013)
Designing Mobile-Based Travel Application using NFC	Stamp Tour Application	The interactive information delivery format using NFC.	Jeong S. R. et al., (2014).

However, most of these applications are offering simple one-way information such as texts, pictures and videos and do not considered users' behaviors. Also, these applications have miner disadvantages that there are no methods for users to feel accomplishment and enjoy entertainment elements of contents for the same reason.

On the other hand, "My Exploration of cultural heritage (2013)" and "Stamp Tour Application (Jeong S. R. et al., 2014)" solved these drawbacks and implemented application which meets user's needs by adopting interactive communication system.

Therefor in this paper, we analyzed and benchmarked these two applications as the appropriate use-cases which inducing users' active participation to design well-structured system for the proposed system.

The Analysis of Contents of History and Culture Applications

As stated above, there are many types of applications focused on history and culture. Because of features of these topics, history and culture, those types of applications contain educational contents even they developed for other purpose. For designing well-structured system and standardizing consistent contents for educational efficiency, we analyzed contents organization of those applications. Followings are the different types of applications and their contents which have their own formal contents structure.

Table II. Different Types of History and Culture Applications and their Contents Organization.

Application Name	Contents Structure	Source
Today History Calendar	Historical events: Date, Short description Great man: Portrait, Name, Birth, Death, Achievement	Today History Calendar(2013)
The information of historical expedition	The lists of Heritage: Name, Detailed description, Additional information (Historical backgrounds, Admission, Open Hours, Location).	The information of historical expedition(2013)
Culture and cultural heritage	Menu : Performances and exhibitions / Cultural properties information, Surrounding information, Information of interest Sub-menu: Type, Region, Period	Culture and cultural heritage(2011)
	Description page: (Official)Name / Period / Type / Region / Location / Contact Us / Related Web-site / General Explanation	
The Korea Heritage	Type of Historical property: World Heritage / National Treasure / Palace / Documentary Heritage / Intangible Heritage URL of detailed Description (Name and description of the shape and additional information)	The Korea Heritage(2013)
Encyclopedia of Korean culture	Description page: Definition / Background / Period and condition / Related information Description page: Definition / Backgrounds and Period / Achievement	Encyclopedia of Korean culture(2013)

As the results from the table, most of applications show the similar contents organization. Typically, (Official) Name, Type, Period, Backgrounds, Related information, and short description are included in the general information. In addition, heritage, admission, open hours and location are included in additional information, and Achievement is for great man.

Based Technologies and Services
Based System Format, Stamp Tour Application
The stamp tour application, proposed by Designing Mobile-Based Travel Application using NFC (Jeong S. R. et al., 2014.), benchmarked the paper stamp tour service and solved their drawbacks using NFC Technology.
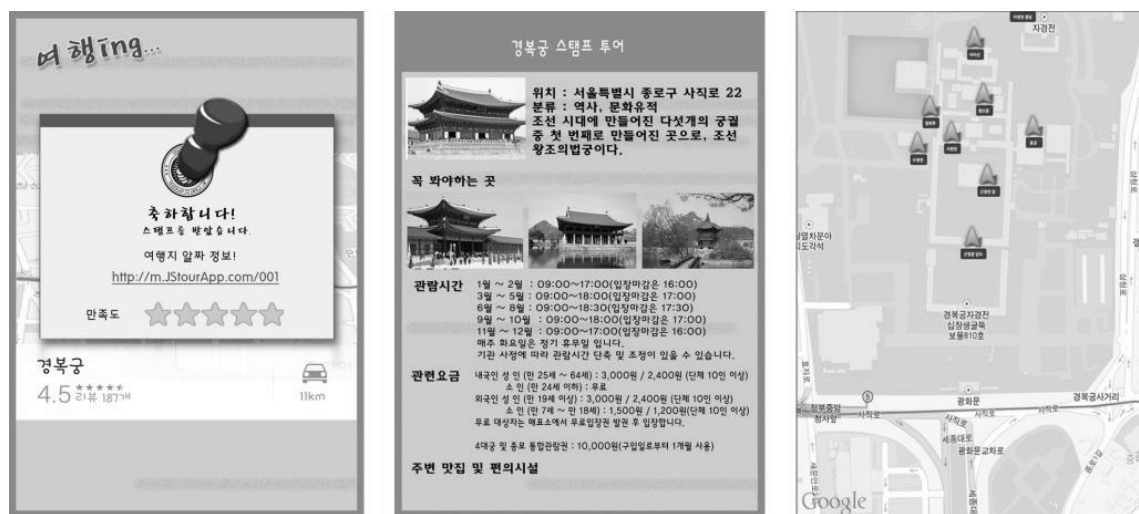
Figure I. JS Stamp Tour Application View

Firstly, maximized mobility using NFC which is embedded system in android-based smart devices. Also, offers real-time location information using open google map API. With this service, users can get additional information for the final destination as well as surroundings. For using this application users have to go and tag the tags on specific location showed on the application. This is our main feature to benchmark for encouraging users' voluntary participation screen. However, this application has no formal contents structure yet and is a little lack in game elements.

Therefore we standardized the structure of contents by conducting the survey and brought the g-learning system from other application in our proposed system. Also to enhance the strength of the interactive participatory system, considered adopting the SNS service and multimedia contents.

Analysis of G-learning Application, My Exploration of Cultural Heritage (2013)
G-learning means the teaching and learning method using games as a tool for learning. It has following distinctions against the existing educational application contents. Firstly, trainees

have the opportunity to experience the educational contents directly or indirectly. Secondly, trainees can interact with system, trainer, and other trainees.

Followings are the analysis of the My Exploration of Cultural Heritage (2013), history educational application which shows the distinctions of g-learning well. This application induced users to go and find the historical sites by offering them missions. Through this process the learning environment is naturally made by this experience. After they find the specific historical sites, the quizzes related to the sites are shown on the screen. The answer of the quiz and the detailed description of the heritages are shown on the same page. Users, trainees of this application, naturally learn the historical and cultural heritages by repeating these processes showing the features of g-learning.

Figure II. My Exploration of Cultural Heritage Application Mission and Quiz View

However, like other applications, this application also has no formal structured contents for detailed description of heritages which is using for educational purpose.

Therefore, our proposed system offers users specific purpose of learning by giving them missions and quizzes as well as standardized contents for improving educational efficiency.

Figure III. Heritage Description Page of the Application

NFC

This application adopted NFC (Near field communication) service which requires less than 4 centimeters of recognition distance. So NFC compatible devices or tag should be brought together closely, or simply touched by themselves(Ok. K. et al., 2010). This short transmission range means that use of NFC technology could encourage user's participation by asking them to move closer to NFC devices or tags.

NFC has three operating modes, P2P (Peer-to-Peer), Reader/Writer, and Card Emulation. P2P mode enables 2 devices to communicate with each other by touching themselves to exchange and share data. Card emulation mode enables NFC device to act like smart card and allows users to perform smart payment such as mobile payment, membership service and transit access control. Lastly, Reader/Writer Mode enables NFC devices and NFC tags to read and modify data (NFC Forum, 2014). This application uses Reader/Writer mode among three operating modes. With this mode, after users access to the application and tag the tags which are pre-set on the specific locations like information board of historical sites or designated buildings, they can be issued the stamp and can get additional information for those locations or buildings.

**Proceedings of 2014 International Conference on
Technology Innovation and Industrial Management
28th-30th May 2014, Seoul, South Korea**

SYSTEM IMPLEMENTATION AND STANDARDIZATION

System Implementation

As the figure IV, after users start the application, buttons of "Study", "Stamp Tour" and "Stamp Passport" are shown on the screen. Study menu has two submenus, "Preparation" and "Review". In the preparation session there is general information of each content for preparation study and in the review session there are the lists of the quizzes users have been answered before. In the Stamp Tour menu there are the lists of the specific destinations to choose and after users choose one destination the screen shows the notification "On the Journey". If users tag the NFC tag at the stat point of the journey, they get the black and white
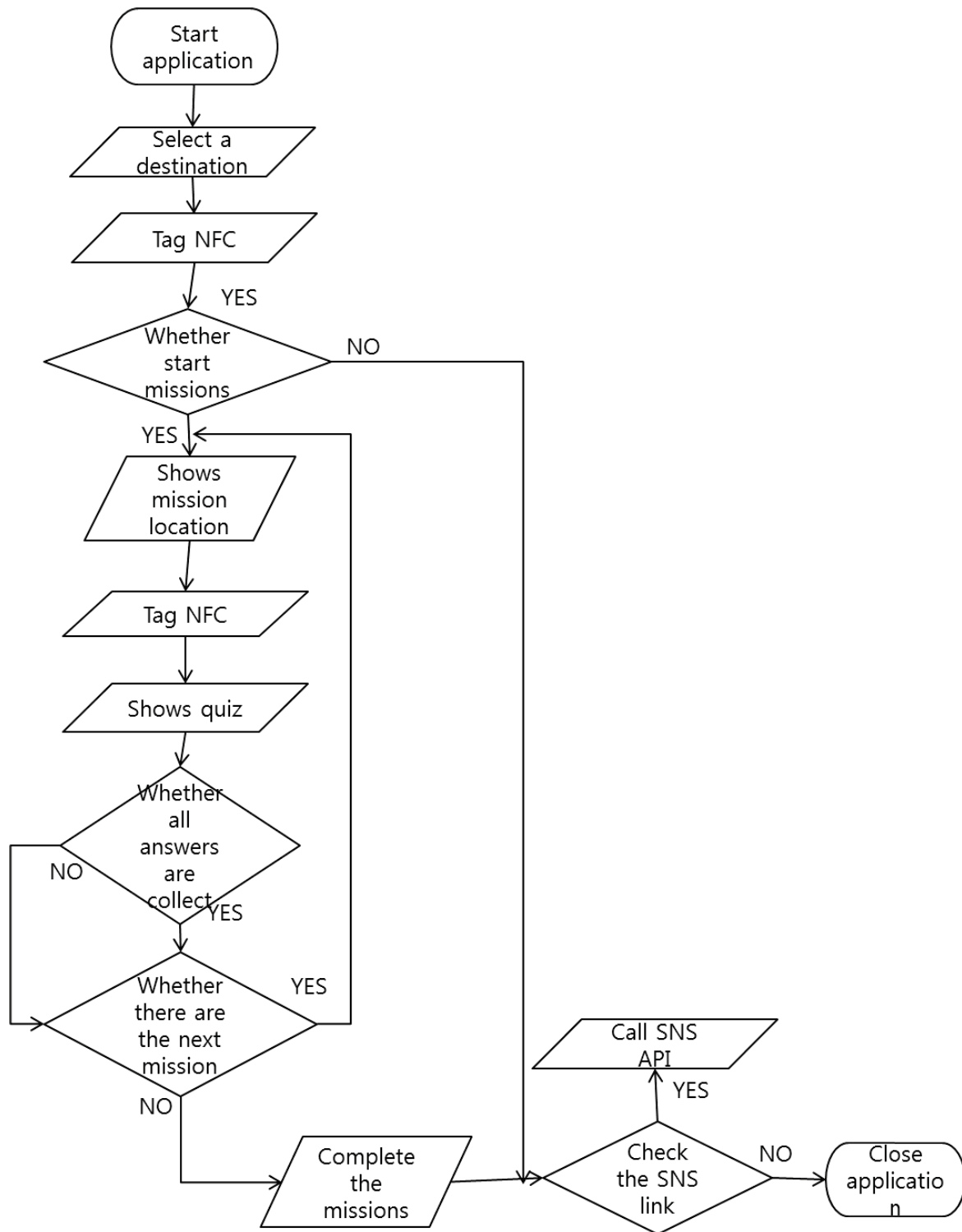
Figure IV. System Flowchart

"Tourist Stamp". After that they could start the mission. Users who start the mission are explained the next location in the new page. As the first process progressed at the start point of the journey if users tag the appropriate NFC tags in the designated location of the mission they can get one of the "Challenger Stamp" and the quizzes related to that mission location

are shown on the screen. Users who answered all the quizzes correctly can get the "Master Stamp" and after finish the quiz mission they can see the standardized list of the explanation of the heritages. After repeat the process until the all the missions are over the final test is offered. Before all the process is over, the black and white Tourist Stamp is changed to the "Gold-Tourist Stamp". In addition, for the convenience and usability for the users, they can upload the texts or pictures of the sites using SNS pre-installed in users' smart mobile device.
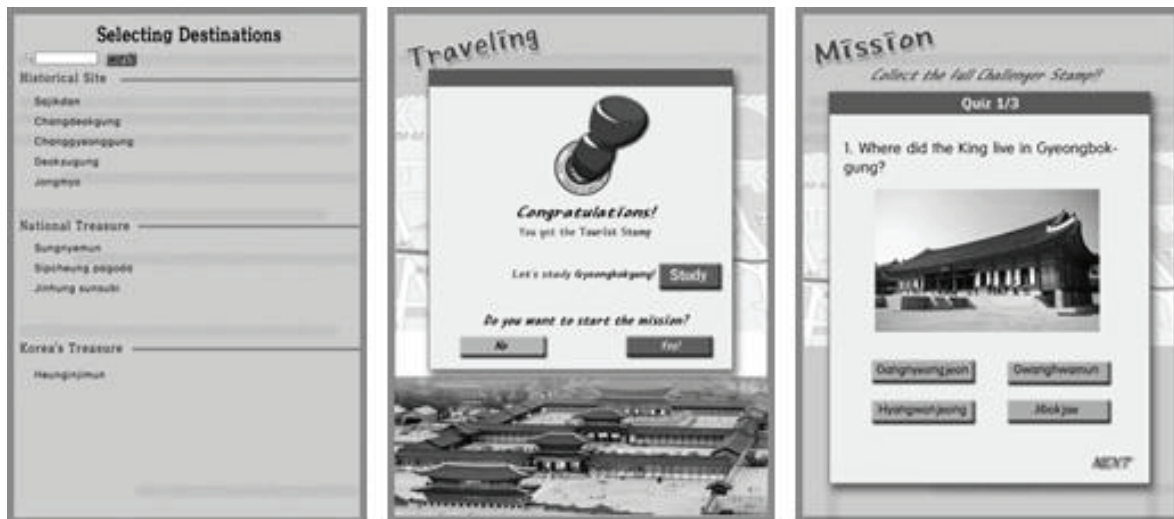
Figure V. The Example View of Proposed Application

Contents Standardization

The purpose of the contents standardization of this proposed application is to establish the appropriate system structure by extracting the common elements from overall system structure for managing the learning materials and information efficiently and distributing them smoothly. Therefore, through the analysis of contents for history and culture application, 1.2 in theoretical backgrounds, we designed the general system structure and organized the educational elements using the data from existing history educational applications. Also we improved the accuracy and reliability of the contents standardization result by comparing the common elements which is earned from the analysis of the use-cases and user surveys. Figure VI is the survey paper we conducted.

Figure VI. The Survey Paper (Korean)

Followings are the obtained results.

1) To evaluate the learning achievement for users offers a simple test after each session.
2) The ideal view is composed of four or five contents in each screen for the effective information delivery.
3) Most of the people answered the Official Title, Cultural Value or Type, and Historical background is highly recommended for informing the historical value of historic and cultural heritages.

Figure VII is the prototype of the application view in response to these results.

CONCLUSIONS

The purpose of this paper is to propose the new concept of the system which satisfies users demand and help them learn history and culture more easily and naturally. We solved the drawbacks of the existing services by using NFC technology and standardizing the structure of contents for the efficiency and usability. Firstly, offers the information what users' want to know

Figure VII. The Prototype of Contents Structure

by analyzing the users' needs from the survey. Secondly, encourages users' active participation by using NFC technology that makes users have to go out and tag at the specific location. Next, makes users learn history and culture more easily and naturally by giving them the repeated quizzes with game format and preparation and review session for more study. Finally, can offer the service for foreigner with multi-language service and furthermore it is possible to apply services to domestic as well as internationals.

However, it has the limits that the service can be implemented only in android-based devices not in IOSs and must be approved by the government or administrators of the heritages because the NFC tags have to be attached on somewhere. These issues should be supplemented by giving the QR cord on the NFC tag for the IOS users and presenting the possibilities of business expansion to the ministry officials.

REFERENCES

1. Jeong S. R., Jung S. J., Ryu K. D., Moon B. J.m Chun J. H., Kim W. J., Kim, J. H. (2014), "Designing Mobile-Based Travel Application using NFC", in the Korea Society of Computer Information Winter Conference 2014, *Daejeon, Korea, 2014, KSCI, pp. 127-130.*

2. *Kim K. S. (2014), "Korean History Linked Open Data", in Linked Open Data Annual Conference 2014, Seoul, Korea, 2014, LODAC, pp.212-237.*

3. Lim J.T., and Suh K.S.(2011), "Study on developing E-learning for history education applying Conceptual map" in *HCI 2011, Korea, 2011,* pp. 869-872

4. Ok K., Coskun V., Aydin M. N., and Ozdenizci B. (2010), "Current Benefits and Future Directions of NFC Services", in *2010 International Conference on Education and Management Technology in Cairo, Egypt, 2010,* IEEE, pp. 334-338.

5. Son M. J. (2012), "Analysis of Awareness of Educational Content and Actual Conditions fits Use in a Smart Learning Environment", in *Graduate School of Education, Kyungpook National University, Daegu, Korea.*

6. Wi J.H., Won E.S. (2013), "A Case Analysis of Entry in Global Education Market focused on Public Education : The Entry of G-Learning(Game Based Learning) into a Public School System in USA", Journal of International Commerce and Information Vol.15 No.2, pp. 109-128.

7. Won E.S., Wi J.H. (2012), " Effectiveness of G-Learning(Teaching and Learning Methodology utilizing Game) adopted in an English Class for 5th Grade Elementary School Students", Journal of Korea Contents Association Vol.12 No.10, pp. 541-554.

8. Electronic Sources:

   1) International Data Corporation, IDC (2014), "Worldwide Smart Device Tracker", available at http://www.idc.com/ (accessed 23 January 2014).

   2) NFC Forum (2014), "What is NFC?, What It Does." , available at: http://nfc-forum.org/ (accessed 25 March 2014).

   3) Portio Research (2014), "Mobile Application Futures.", available at: http://www.portioresearch.com/ (accessed 23 January 2014).

   4) Google play
      A. "Art Day (2013)", available at: https://play.google.com/store/apps/details?id=com.appknot.artday (accessed 15 March 2014).
      B. "Bekje History Tour (2014)", available at: https://play.google.com/store/apps/details?id=storytellring.baekje.ot (accessed 15 March 2014).
      C. "Culture and cultural heritage (2011)", available at: https://play.google.com/store/apps/details?id=com.mfac.cultureTour (accessed 16 March 2014).

D. "Daehak-ro performance information (2014)", available at: https://play.google.com/store/apps/details?id=app.SFACB (accessed 15 March 2014).

E. "Encyclopedia of Korean culture (2013)", available at: https://play.google.com/store/apps/details?id=kr.ac.aks.mgc (accessed 16 March 2014).

F. "History Books (2014)", available at: https://play.google.com/store/apps/details?id=manyapps.net.manibukfree.history (accessed 15 March 2014).

G. "History Calendar (2013)", available at: https://play.google.com/store/apps/details?id=com.panez.historycalendar (accessed 15 March 2014).

H. "History Quiz Expedition (2014)", available at: https://play.google.com/store/apps/details?id=air.sunmoon.historyQuiz (accessed 15 March 2014).

I. "I am Korean (2013)", available at: http://nstore.naver.com/appstore/web/detail.nhn?productNo=1027625 (accessed 15 March 2014).

J. "Korean History Timeline (2014)", available at: https://play.google.com/store/apps/details?id=com.chohk.kor_hkl (accessed 15 March 2014).

K. "My Exploration of cultural heritage (2013)", available at: https://play.google.com/store/apps/details?id=com.kr.mydapsa (accessed 15 March 2014).

L. "Silla History Tour (2014)", available at: https://play.google.com/store/apps/details?id=storytellring.ot (accessed 15 March 2014).

M. "The Heritage of Korea (2013)", available at: https://play.google.com/store/apps/details?id=kr.mirim.solution.tkh2 (accessed 16 March 2014).

N. "The History of Korea (2013)", available at: https://play.google.com/store/apps/details?id=com.appcookr.app_kr_2855 (accessed 16 March 2014).

O. "The review of mission trips to Gyeongbok palace (2013)", available at: http://mydapsa.net/ (accessed 16 March 2014).

CAN MULTICULTURAL EXPERIENCE STIMULATE CREATIVITY?

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ABSTRACT

Purpose: In the face of fierce international competition and rapidly changing technologies, the enhancement of creativity among employees is vital for organizations seeking to maintain their competitive advantage. Globalization has provided employees with a wider range of multicultural experiences, which a number of studies have found to stimulate creativity. Nonetheless, the boundary conditions of this influence have yet to be fully elucidated. The study draws on cognitive tuning and regulatory focus theory perspectives to addresses the moderating effect of regulatory focus on the relationship between multicultural experience and creativity.

Design/methodology/approach: This study investigated whether one's regulatory focus moderates the relationship between multicultural experience and creativity. We adopted an experimental approach using a 3×2 between-group design based on the manipulation of multicultural experience (Taiwanese or American culture (single cultural exposure), and both Taiwanese and American culture (dual cultural exposure)) and regulatory focus (promotion focus and preventative focus) with 120 university students (study 1) and 120 workers in the workplace (study 2) as participants.

Findings: The results of evaluating the creativity of the participants indicated that multicultural experience exerts a significant influence on creativity; the creativity demonstrated by participants in multicultural scenarios was superior to that in scenarios featuring only one culture. Furthermore, regulatory focus moderates the relationship between

multicultural experience and creativity, such that multicultural experience had a significant influence on creativity in circumstances with a focus on promotion but no apparent effect in circumstances with a focus on prevention.

Originality/Value: *Our research demonstrates that the relationship between creativity and the interaction effects of multicultural experience and regulatory focus. This contribution to understanding the influence of creativity extends theory on multicultural experience, regulatory focus, and creativity. Moreover these results have important implications for human resource management and global learning.*

Keywords: creativity, multicultural experience, regulatory focus

Article Classification: Research paper

INTRODUCTION

In a dynamic environment with fierce international competition, rapidly changing technological innovation, high external uncertainty, and shorter product life cycles, corporations must constantly enhance their innovative capacity to satisfy customer needs. Creativity is the only way to maintain a competitive advantage (Amabile, 1983).

Globalization has made it easier to gain multicultural experience through study, travel, and work in other countries and through the flow of culture across borders. The processes involved in gaining, considering, and learning from such experiences can be catalysts for the promotional of creativity. Many cultural psychologists have claimed that multicultural experiences can stimulate creativity (Maddux & Galinsky, 2009; Leung & Chiu, 2010).

Researchers examining the relationship between multicultural experience and creativity have combined social identity theory with the creative cognition approach, leading to the discovery that identity integration is positively correlated to the strength of multicultural experiences and performance in creativity (Cheng, Sanchez-Burks, & Lee, 2008). Furthermore, multicultural experience can act as a stimulant of creativity by adding to the optimistic/pessimistic views of diversity (Leung, Maddux, Galinsky, & Chiu, 2008). Many empirical studies have discovered that multicultural experience can enhance personal creativity (Cheng et al., 2008; Leung & Chiu, 2010). However, the influence of multicultural experience may be affected by boundary conditions concerning the time constraints, the need for cognitive closure, mortality salience, and the emotional feelings generated in response to the evaluation of cultural stimulation (Cheng, Leung & Wu, 2011).

Many circumstantial factors can influence the connection between multicultural experience and creativity, including the need for cognitive closure, mortality salience, and regulatory focus. Regulatory focus theory holds that the means by which individuals interpret and handle information depends on contingencies associated with regulatory focus. The phenomenon in which motives behind regulatory focus induce changes in creativity can be explained by the style of cognitive tuning (Friedman & Forster, 2001; Seibt & Forster, 2004), which influences the creativity demonstrated by individuals. Therefore, this study further explores the relationship between the interaction of multicultural experience and regulatory focus on creativity, thereby clarifying the boundary conditions concerning the effects of multicultural experience on creativity.

LITERATURE REVIEW AND HYPOTHESES

Creativity

Guildford (1950) initiated research into the nature of creativity. Researchers have made considerable developments in this field; however, creativity is a complex process with numerous definitions and related theories. Creativity is generally defined as the ability to produce novel and useful ideas or products (Amabile, 1983) and solve problems using original methods (Paulus & Nijstad, 2003). Creativity has been identified as a major component of innovation (Mumford & Gustafson, 1988).

Creativity is crucial to the success of organizations and is a core capability required for their long-term survival. Fostering creativity in an organization requires that the meaning of creativity, as well as the factors influencing it, be fully understood. A number of researchers have studied the situational factors influencing creativity, such as temporary changes in the emotional state of an individual (Hirt, Devers, & McCrea, 2008), differences in the perception of time (Forster, Friedman, & Liberman, 2004), and regulatory focus (Friedman & Forster, 2001; Seibt & Forster, 2004).

This study conducted an in-depth investigation to reveal the relationship between creativity and multicultural experience and the motives behind regulatory focus to clarify the boundary conditions associated with the influence of multicultural experience on creativity.

Multicultural experience and creativity

The creative cognition approach has become an important concept in the study of creativity and its associated processes (Wan & Chiu, 2002). This study was conducted under the assumption that creativity develops much like any other type of cognition in our daily lives. From this perspective, anyone who can make effective use of routine cognitive processes can produce extraordinary creative achievements (Finke et al., 1992). Thus, individual creativity can be enhanced by building a suitable environment and stimulating personal creative cognition.

The theory underlying creative cognition approach specifies that creative thinking involves two types of cognitive processes: generative processes and exploratory processes (Finke et al., 1992). During the generative processes, an individual actively searches for relevant information and comes up with ideas with which to generate candidate solutions. The candidate solutions are then reviewed in detail to identify those warranting further treatment, such as modification, elaboration, and transformation in what is referred to as exploratory processes. Effective utilization of generative processes can help to conceptual expansion, which occurs when attributes of seemingly irrelevant concepts are added to an existing concept to extend its conceptual boundary (Wan & Chiu, 2002).

Multicultural experience refers to all direct and indirect experiences of encountering or interacting with elements and/or members of foreign cultures. Multicultural experience may foster the creative expansion of ideas. From this perspective, multicultural experience influences creativity by generating creative cognition, which induces an individual to undergo the process of obtaining, organizing, handling, storing, and using relevant information. Multicultural experience involves an expanded number of stimulants and exchanges and can add to the optimistic/pessimistic views of diversity; thus, it can enhance creativity (Leung et al., 2008). We therefore posit that

> H1: The multicultural experiences of an individual can enhance his or her personal creativity.

Multicultural experience, regulatory focus, and creativity

When an individual gains multicultural experience, they also encounter stimulants and forms of exchange that broaden their conceptual boundaries. From the perspective of cognitive flexibility (Spiro et al., 1987), an individual transfers and adapts to knowledge according to the environment and his or her personal background through the reconstruction of knowledge, which enables him or her to respond appropriately in situations involving fundamental changes requiring cultural abilities beyond those found in his or her own culture. This can be referred to as cross-cultural innovative ability. Acquiring multicultural experience can enhance cognitive flexibility and alter the perception of individuals with regard to their ability to connect two cultures, which ultimately enhances their creativity. However, the influence of multicultural experience on creativity is not stable or unchanging; an individual's style of crucial tuning can moderate this influence, and regulatory focus is a vital moderating factor in this process.

Higgins (1997) divided regulatory focus into two types of motivation, promotional motivation and preventative motivation, stating that individuals with different types of regulatory focus have different motivations, objectives, intentions, and strategies. Promotion-focused individuals strive to satisfy their ideal goals, gaining pleasure at the appearance of positive results (gains) and pain at the disappearance of positive results (non-gains). These individuals tend to use approach strategic means to achieve their goals and

ensure positive results. In contrast, preventative-focused individuals seek the satisfaction derived from security and pursue goals according to what they perceive as necessary, gaining pleasure at the disappearance of negative results (non-losses) and pain at the appearance of negative results (losses). Ensuring the avoidance of negative results involves the adoption of avoidance strategic means.

The changes induced by regulatory focus can be explained according to the cognitive tuning style adopted by the individual. Individuals with promotional motivation are likely to feel secure about the environment and thus be more adventurous, resulting in the adoption of a more exploratory method of handling problems. This increases their cognitive flexibility when acquiring multicultural experience, which tends to enhance creativity. In contrast, individuals with a more preventative motivation perceive the environment as threatening, leading them to dislike adventure and handle problems using a more structured approach. This weakens their cognitive flexibility when acquiring multicultural experience, which tends to stifle creativity. Many studies have demonstrated that promotional motivation can enhance creativity, whereas preventative motivation inhibits it (Friedman & Forster, 2001; Seibt & Forster, 2004). We can therefore assume that regulatory focus moderates how multicultural experience influences creativity. Thus, we hypothesize that

> H2: The interaction between the multicultural experience and the motivation guiding the regulatory focus of an individual influences personal creativity. Promotional motivation strengthens the influence of multicultural experience on creativity, whereas preventative motivation weakens the influence of multicultural experience on creativity.

METHODOLOGY

Study 1
Participants
The participants were 120 Taiwan students (68 females and 52males; mean age = 21.03) undergraduate business students participating for course extra credit at a university located in Northern Taiwan, who took part in the study in exchange for NT$100. Participants were randomly assigned to conditions.

Experimental design and procedure
The instruments used in the experiment included three scenarios associated with multicultural experience (Cheng et al., 2011) based on Taiwanese culture, American culture, and both Taiwanese and American culture as well as two regulatory focus models for promotional motivation and preventative motivation. Six versions (A, B, C, D, E, and F) were designed using slideshow depicting different characteristic aspects and the two regulatory focus models. The experiments were implemented by group in a computer laboratory with each student assigned to a computer, which randomly presented one of the six experiment

scenarios.

The procedure of the experiment involved having the participants watch a 10-min multicultural experience video comprising 72 pictures related a single local cultural entity (Taiwanese culture; for example, Chiang Kai-shek Memorial Hall), a single foreign cultural entity (American culture; for example, the White House), or both local and foreign cultural entities (both Taiwanese and American culture; for example, American culture on the left and Taiwanese culture on the right). The participants were then asked to describe their feelings and opinions regarding the 10-min slideshow.

In the second stage, the participants were asked to play the role of Millet the Mouse. Various tasks related to regulatory focus were designed (Friedman & Forster, 2001) to generate promotional and preventative motivation. In the promotional motivation scenario, Millet searches for a way through a maze to find a piece of cheese. In the preventative motivation scenario, the cheese is replaced with an owl, which is circling overhead and preparing to catch Millet. To escape the owl and get home safely, Millet must find a way out of the maze. Once the maze was completed, the participants filled out a questionnaire concerning their regulatory focus motivation (such as "Do you want the cheese?" or "Are you cautiously avoiding the owl's capture?") and emotional state (such as "Do you feel happy now?" or "Do you feel anxious now?"), which were measured on a seven-point Likert scale from 1 (strongly disagree) to 7 (strongly agree).

In the third stage, we created measures of creativity based on the Unusual Uses Test. The participants were asked to list five things that they would most like to give a close acquaintance (Leung & Chiu, 2010). We referred to Barsalou (1985) and Battig and Montague (1969) to categorize the gifts, processing minor differences (such as flowers and a bouquet of flowers) and synonyms (such as cash and money). We then evaluated creativity using the scoring method proposed by Ward et al. (2002). Ideas that appeared more frequently or nearer to the top of the lists earned higher points. Total scores exceeding the average indicated a lack of creativity.

Lastly, the participants were asked to fill out their personal information and write about their personal identification and familiarity with the two cultures (Taiwanese and American) as a manipulation check. These answers were recorded using a 10-point Likert scale (1 for not at all familiar (strongly not identifying) and 10 for extremely familiar (strongly identifying)). Following the experiment, the purpose of the study was explained to the participants.

Results and discussion

Results of manipulation check

(1) Manipulation check for multicultural experience

To ensure that the manipulation of multicultural experience was valid, we assessed the extent to which the participants were familiar with or identified with the two cultures involved in this study. The degree of familiarity with Taiwanese culture was generally higher than that with American culture. Analysis of the self-reports indicated a mean familiarity of M_{Taiwan}=6.97 with a standard deviation of SD_{Taiwan}=1.20 for Taiwanese culture in contrast to a mean familiarity of M_{American}=5.42 and a standard deviation of SD_{American}=1.36 for American culture. Thus, the participants were significantly more familiar with Taiwanese culture than with American culture ($F(1,236)$=86.65; p<0.001). As for identification, the results produced a mean of M_{Taiwan}=7.19 and a standard deviation of SD_{Taiwan}=1.44 for Taiwanese culture and a mean of M_{American}=5.73 with a standard deviation of SD_{American}=1.58 for American culture. Therefore, the participants identified with Taiwanese culture significantly more than they did with American culture ($F(1,236)$=55.55; p<0.001). The results show that individuals with exposure to local as well as foreign culture perceived a higher degree of self-relevance with regard to local culture than to foreign culture. Thus, this manipulation conformed to the objectives of this study and was valid.

(2) Manipulation check for regulatory focus

To ensure the validity of the manipulation with regard to regulatory focus, we evaluated the motivations behind regulatory focus and the emotional status of the participants following the regulatory focus manipulation. Desire, hope, and effort are attributed to promotional motivation, whereas vigilance and caution are attributed to preventative motivation. Excitement and happiness are associated with a focus on promotion, and anxiety is associated with a focus on prevention. Thus, a manipulation check was performed using these indicative differences after generating promotional and preventative motivation. The analysis results indicate that in terms of a focus on promotion, the mean and standard deviation for motivation were M_{Motive1}=5.53, SD_{Motive1}=1.50, M_{Motive2}=5.38, and SD_{Motive2}=1.37. Because we used a seven-point scale, the mean tests presented means significantly greater than 4 ($t_{\text{Motive1}}(59)$=7.91, p<0.001; $t_{\text{Motive2}}(59)$=7.84, p<0.001). In emotional status, the mean and standard deviations were $M_{\text{Emotional1}}$=4.72, $SD_{\text{Emotional1}}$=1.21, $M_{\text{Emotional2}}$=4.60, and $SD_{\text{Emotional2}}$=1.12. Again, the results of the mean test were significantly greater than 4 ($t_{\text{Emotional1}}(59)$=4.59, p<0.001; $t_{\text{Emotional2}}(59)$=4.20, p<0.001). With regard to a focus on prevention, the mean and standard deviations for motivation were M_{Motive1}=4.72, SD_{Motive1}=1.57, M_{Motive2}=5.00, and SD_{Motive2}=1.50. Because we used a seven-point scale, the mean tests presented means significantly greater than 4 ($t_{\text{Motive1}}(57)$=3.52, p<0.001; $t_{\text{Motive2}}(57)$=5.08, p<0.001). In emotional status, the mean and standard deviations were $M_{\text{Emotional1}}$=4.29, $SD_{\text{Emotional1}}$=0.96, $M_{\text{Emotional2}}$=4.31, and $SD_{\text{Emotional2}}$=0.96. Again, the results of the mean test were significantly greater than 4 ($t_{\text{Emotional1}}(57)$=2.34, p<0.05; $t_{\text{Emotional2}}(57)$=2.47, p<0.05). These results show that the manipulation conformed to study objectives and was valid.

Analysis of results concerning the influence of multicultural experience and regulatory focus on creativity

The mean and standard deviation in creativity task scores resulting from the influence of various combinations of multicultural experience and regulatory focus are presented in Fig. 1. In circumstances with a promotion-focus, the mean and standard deviation were $M_{Taiwan}=6.9$ and $SD_{Taiwan}=4.15$ for Taiwanese culture single, $M_{American}=9.5$ and $SD_{America}=5.11$ for American culture single, and $M_{Taiwan-American}=4.40$ and $SD_{Taiwan-American}=2.84$ for Taiwanese and American cultures dual. This demonstrates that situations involving both Taiwanese and American culture tended to stimulate creativity to a greater extent than situations dealing only with Taiwanese or American culture. In terms of a preventative-focus, the mean and standard deviations were $M_{Taiwan}=9.21$ and $SD_{Taiwan}=2.96$ for Taiwanese culture, $M_{American}=8.16$ and $SD_{America}=4.02$ for American culture, and $M_{Taiwan-American}=8.00$ and $SD_{Taiwan-American}=4.63$ for the two cultures dual, indicating that creative performance is enhanced by multicultural experiences to a greater degree than in either of the cultures alone. In the scenario based solely on Taiwanese culture, the mean and standard deviation for promotion-focus were $M_{Promotion}=6.90$ and $SD_{Promotion}=4.15$, and the mean and standard deviation for prevention-focus were $M_{Preventative}=9.21$ and $SD_{Preventative}=2.96$, indicating that in a cultural scenario based solely on Taiwanese culture, a focus on promotion is better than a focus on prevention with regard to creativity. In the scenario with American culture single, the mean and standard deviation were $M_{Promotion}=9.50$ and $SD_{Promotion}=5.11$ for a focus on promotion and $M_{Preventative}=8.16$ and $SD_{Preventative}=4.02$ for a focus on prevention, indicating in a scenario with American culture alone, a focus on prevention is better than a focus on promotion with regard to creativity. In the scenario with Taiwanese and American cultures dual, the mean and standard deviation were $M_{Promotion}=4.40$ and $SD_{Promotion}=2.84$ for a focus on promotion and $M_{Preventative}=8.00$ and $SD_{Preventative}=4.63$ for a focus on prevention, indicating that in a multicultural scenario, a focus on promotion is also better than a focus on prevention with regard to creativity.
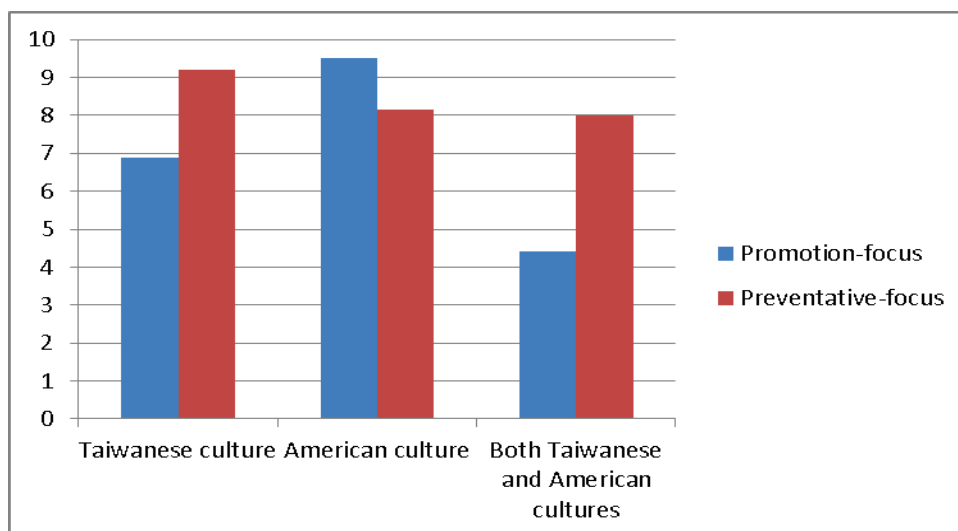
Fig. 1 Comparison of mean scores in creativity-related tasks conducted in the context of six combinations of multicultural experience and regulatory focus

The results of two-way ANOVA, indicating that the main effects of the two independent variables (multicultural experience and regulatory focus), reached the level of significance ($F(2,112)=4.42$, $p<0.05$, effect size $\eta^2=0.07$; $F(1,112)=4.28$, $p<0.05$, $\eta^2=0.04$). The interaction effects of multicultural experience and regulatory focus also reached the level of significance ($F(2,112)=3.95$, $p<0.05$, effect size $\eta^2=0.07$). Furthermore, the profile plots in Fig. 2 display obvious intersections, indicating significant interaction.
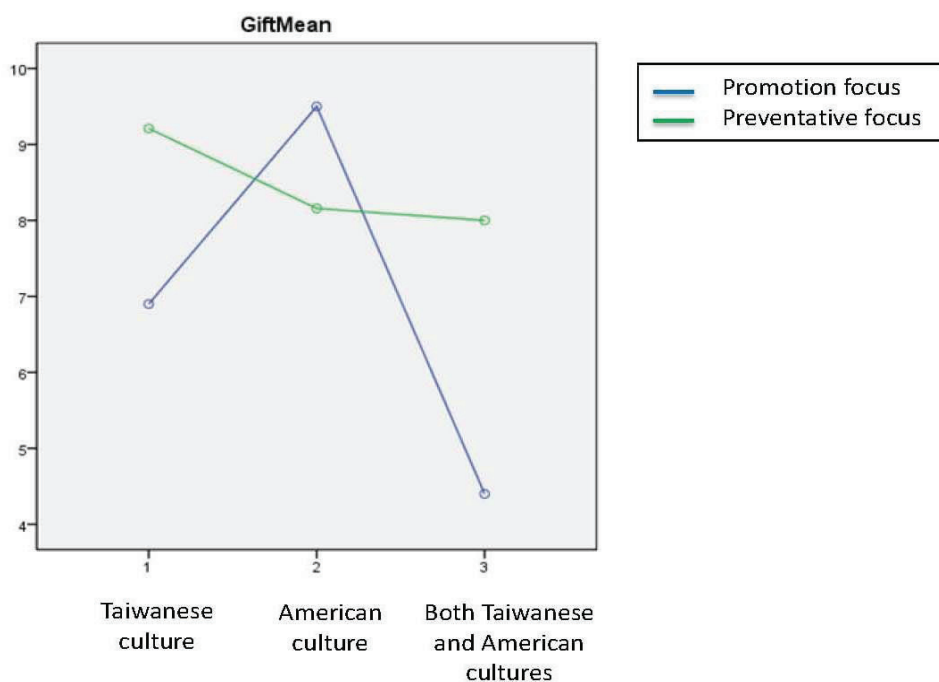
Fig. 2 Profile plots of interaction effects

The interaction effects were significant; therefore, the results were subjected to analysis of simple main effects. The results show significant differences in multicultural experience under a focus on promotion ($F(2,112)=7.58$, $p<0.05$) but no significant differences in multicultural experience under a focus on prevention. In contrast, significant differences appeared in regulatory focus with Taiwanese culture single ($F(1,112)=3.34$, $p<0.05$) and Taiwanese and American cultures dual ($F(1,112)=8.78$, $p<0.05$) but not with American culture single ($F(1,112)=0.83$, $p>0.05$).

Study 2
Participants
The study1 we employed a laboratory design using college students. Some scholars have

raised questions about the external validity of this paradigm (e.g., Gordon, Slade, & Schmitt, 1986, 1987). We committed to test the goal of this study was to investigate a specific causal theory and external validity. We seek to make inferences about a particular work setting. The study2 participants were publicly recruited from Executive MBA students of school of management located in Northern Taiwan. They are working individuals and Taiwanese. Among the 120 participants, 56 were male (46.67 %) and the average age was 38.25.

Experimental design and procedure

The experimental design and procedure is similar the study1. The first stage is the same with study1. In the second stage, the tasks related to regulatory focus is the same with study 1. However, the participants filled out a questionnaire concerning their regulatory focus motivation and emotional state is differences. To improve the regulatory focus manipulation check, study 2 adjust the participants concerning their regulatory focus by 8 items (motivation 4 items and emotional state 4 items), which were measured on a seven-point Likert scale from 1 (strongly disagree) to 7 (strongly agree).

The third stage involved measuring the dependent variables of creativity. Participants were given 10 minutes to complete an Unusual Uses Test (Guilford, 1959)—a widely used creativity tasks that measures people's ability to generate divergent ideas and to devise different strategies for using a common object. In the current study, the participants were asked to list as many uses for garbage bags as possible. They were instructed not to limit themselves to any type of garbage bag or to the uses they had seen or heard about before.

We created two measures of creativity based on the Unusual Uses Test. The first measure, fluency, refers to the total number of unusual uses participants generated after eliminating repetitive responses. The second measure, flexibility, refers to the total number of categories of unusual uses generated. Two independent coders grouped the responses into different categories (e.g., containers, waterproof materials, arts, and furniture) and then counted the number of categories of unusual uses for each participant.

Results and discussion
Results of manipulation check

(1) Manipulation check for multicultural experience

To ensure that the manipulation of multicultural experience was valid, we assessed the extent to which the participants were familiar with or identified with the two cultures involved in this study. The degree of familiarity with Taiwanese culture was generally higher than that with American culture. Analysis of the self-reports indicated a mean familiarity of M_{Taiwan}=7.10 with a standard deviation of SD_{Taiwan}=1.12 for Taiwanese culture in contrast to a mean familiarity of $M_{American}$=5.45 and a standard deviation of $SD_{American}$=1.21 for American culture. Thus, the participants were significantly more familiar with Taiwanese culture than

with American culture ($F(1,238)=120.55$; $p<0.001$). Regarding identification, the results produced a mean of $M_{Taiwan}=7.08$ and a standard deviation of $SD_{Taiwan}=1.34$ for Taiwanese culture and a mean of $M_{American}=5.73$ with a standard deviation of $SD_{American}=1.51$ for American culture. Therefore, the participants identified with Taiwanese culture to a significantly greater extent than with American culture ($F(1,238)=53.74$; $p<0.001$). The results show that individuals with exposure to local as well as foreign culture perceived a higher degree of self-relevance with regard to local culture than to foreign culture. Thus, this manipulation conformed to the objectives of this study and was valid.

(2) Manipulation check for regulatory focus

To ensure the validity of the manipulation with regard to regulatory focus, we evaluated the motivations behind regulatory focus and the emotional status of the participants following the regulatory focus manipulation. Thus, a manipulation check was performed using these indicative differences after generating promotional and preventative motivation. The analysis results indicate that in terms of a focus on promotion, the mean and standard deviation for motivation were $M_{Motive1}=5.78$, $SD_{Motive1}=1.04$; $M_{Motive2}=5.52$, $SD_{Motive2}=1.11$; $M_{Motive3}=2.18$, $SD_{Motive3}=0.54$; and $M_{Motive4}=2.05$, $SD_{Motive4}=0.77$. Applying a paired sample t-test, the paired differences are significant ($t_{Motive1-Motive3}(59)=23.57$, $p<0.001$; $t_{Motive2-Motive4}(59)=19.95$, $p<0.001$). For emotional status, the mean and standard deviations were $M_{Emotional1}=5.80$, $SD_{Emotional1}=0.66$; $M_{Emotional2}=6.18$, $SD_{Emotional2}=0.81$; $M_{Emotional3}=2.02$, $SD_{Emotional3}=0.50$; and $M_{Emotional4}=1.82$, $SD_{Emotional4}=0.65$. The paired differences are significant ($t_{Emotional1-Emotional3}(59)=42.40$, $p<0.001$; $t_{Emotional2-Emotional4}(59)=28.03$, $p<0.001$). With regard to a focus on prevention, the mean and standard deviations for motivation were $M_{Motive1}=2.52$, $SD_{Motive1}=0.92$; $M_{Motive2}=2.70$, $SD_{Motive2}=0.81$; $M_{Motive3}=6.10$, $SD_{Motive3}=0.63$; and $M_{Motive4}=6.40$, $SD_{Motive4}=0.62$. Applying a paired sample t-test, the paired differences are significant ($t_{Motive1-Motive3}(59)=-25.03$, $p<0.001$; $t_{Motive2-Motive4}(59)=-29.26$, $p<0.001$). For emotional status, the mean and standard deviations were $M_{Emotional1}=2.20$, $SD_{Emotional1}=0.68$; $M_{Emotional2}=2.42$, $SD_{Emotional2}=0.85$; $M_{Emotional3}=6.28$, $SD_{Emotional3}=0.39$; and $M_{Emotional4}=6.25$, $SD_{Emotional4}=0.60$. The paired differences are significant ($t_{Emotional1-Emotional3}(59)=-37.96$, $p<0.001$; $t_{Emotional2-Emotional4}(59)=-26.82$, $p<0.001$). These results show that the manipulation conformed to study objectives and was valid.

Analysis of results concerning the influence of multicultural experience and regulatory focus on creativity

For the creativity measures of fluency and flexibility, the mean and standard deviation of the creativity task scores resulting from the influence of various combinations of multicultural experience and regulatory focus are presented in Figs. 3 and 4. In circumstances with a promotion focus, the mean and standard deviation of fluency were $M_{Taiwan}=8.10$ and $SD_{Taiwan}=1.02$ for Taiwanese culture, $M_{American}=5.15$ and $SD_{American}=1.04$ for American culture, and $M_{Taiwan-American}=9.20$ and $SD_{Taiwan-American}=1.00$ for both Taiwanese and American culture. The mean and standard deviation for flexibility were $M_{Taiwan}=2.60$ and $SD_{Taiwan}=0.50$ for Taiwanese culture, $M_{American}=2.05$ and $SD_{American}=0.61$ for American culture, and

$M_{\text{Taiwan-American}}$=3.10 and $SD_{\text{Taiwan-American}}$=0.64 for both Taiwanese and American culture. These findings demonstrate that situations involving both Taiwanese and American culture tended to stimulate creativity to a greater extent than situations involving only Taiwanese or only American culture. In terms of a preventative focus, the mean and standard deviations of fluency were M_{Taiwan}=6.15 and SD_{Taiwan}=0.93 for Taiwanese culture, M_{American}=7.15 and SD_{American}=0.75 for American culture, and $M_{\text{Taiwan-American}}$=7.30 and $SD_{\text{Taiwan-American}}$=0.92 for both cultures. The mean and standard deviation for flexibility were M_{Taiwan}=2.25 and SD_{Taiwan}=0.55 for Taiwanese culture, M_{American}=2.60 and SD_{American}=0.60 for American culture, and $M_{\text{Taiwan-American}}$=2.35 and $SD_{\text{Taiwan-American}}$=0.49 for both Taiwanese and American culture. These findings indicate that creative performance is enhanced to a greater degree by multicultural experiences than by the experiences of either culture alone. In the scenario based solely on Taiwanese culture, for fluency, the mean and standard deviation were $M_{\text{Promotion}}$=8.10 and $SD_{\text{Promotion}}$=1.02 for promotion focus and $M_{\text{Preventative}}$=6.15 and $SD_{\text{Preventative}}$=0.93 for prevention focus, respectively. For flexibility, the mean and standard deviation were $M_{\text{Promotion}}$=2.60 and $SD_{\text{Promotion}}$=0.50 for promotion focus and $M_{\text{Preventative}}$=2.25 and $SD_{\text{Preventative}}$=0.52 for prevention focus, respectively, indicating that in a cultural scenario based solely on Taiwanese culture, a focus on promotion is better than a focus on prevention with regard to creativity. In the scenario based solely on American culture, for fluency, the mean and standard deviation were $M_{\text{Promotion}}$=5.15 and $SD_{\text{Promotion}}$=1.04 for a focus on promotion and $M_{\text{Preventative}}$=7.15 and $SD_{\text{Preventative}}$=0.75 for a focus on prevention, respectively. For flexibility, the mean and standard deviation were $M_{\text{Promotion}}$=2.05 and $SD_{\text{Promotion}}$=0.62 for a focus on promotion and $M_{\text{Preventative}}$=2.60 and $SD_{\text{Preventative}}$=0.60 for a focus on prevention, respectively, indicating that in a scenario with American culture alone, a focus on prevention is better than a focus on promotion with regard to creativity. In the scenario with both Taiwanese and American cultures, the mean and standard deviation for fluency were $M_{\text{Promotion}}$=9.20 and $SD_{\text{Promotion}}$=1.00 for a focus on promotion and $M_{\text{Preventative}}$=7.30 and $SD_{\text{Preventative}}$=0.92 for a focus on prevention, respectively. The mean and standard deviation for flexibility were $M_{\text{Promotion}}$=3.10 and $SD_{\text{Promotion}}$=0.64 for a focus on promotion and $M_{\text{Preventative}}$=2.35 and $SD_{\text{Preventative}}$=0.49 for a focus on prevention, respectively, indicating that in a multicultural scenario, a focus on promotion is also better than a focus on preventation with regard to creativity.
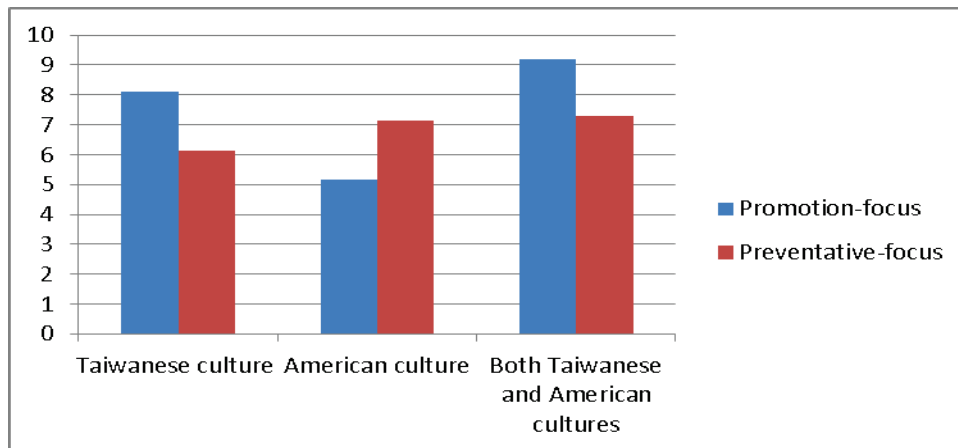
Fig. 3 Comparison of mean scores in creativity-related tasks (fluency) conducted in the context of six combinations of multicultural experience and regulatory focus
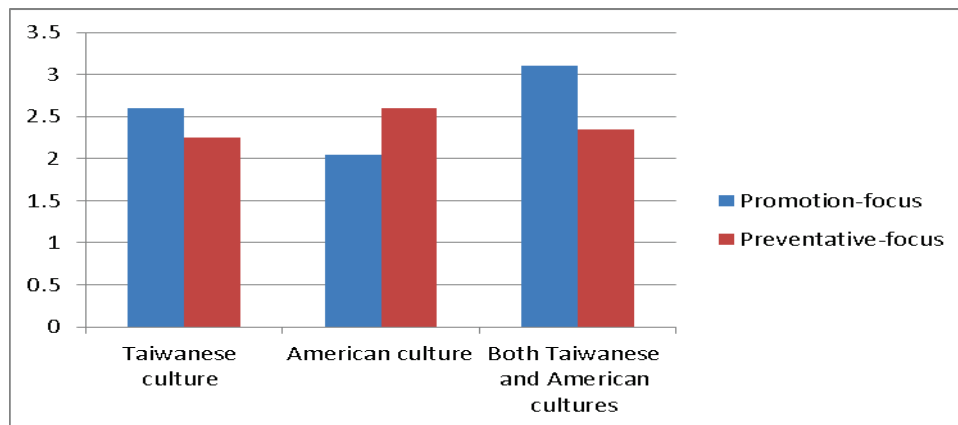
Fig. 4 Comparison of mean scores in creativity-related tasks (flexibility) conducted in the context of six combinations of multicultural experience and regulatory focus

The results of two-way ANOVA for fluency and flexibility, indicating that the main effects of the two independent variables (multicultural experience and regulatory focus) reached the level of significance (fluency: $F(2,114)=48.96$, $p<0.05$, effect size $\eta^2=0.46$; $F(1,114)=12.65$, $p<0.05$, $\eta^2=0.10$; flexibility: $F(2,114)=5.39$, $p<0.05$, effect size $\eta^2=0.09$; $F(1,114)=3.14$, $p=0.08$, $\eta^2=0.03$). The interaction effects of multicultural experience and regulatory focus also reached the level of significance (fluency: $F(2,114)=56.93$, $p<0.05$, effect size $\eta^2=0.50$; flexibility: $F(2,114)=13.79$, $p<0.05$, effect size $\eta^2=0.20$). Furthermore, the profile plots in Fig. 5 and Fig. 6 display obvious intersections, indicating significant interaction.

FluencyMean
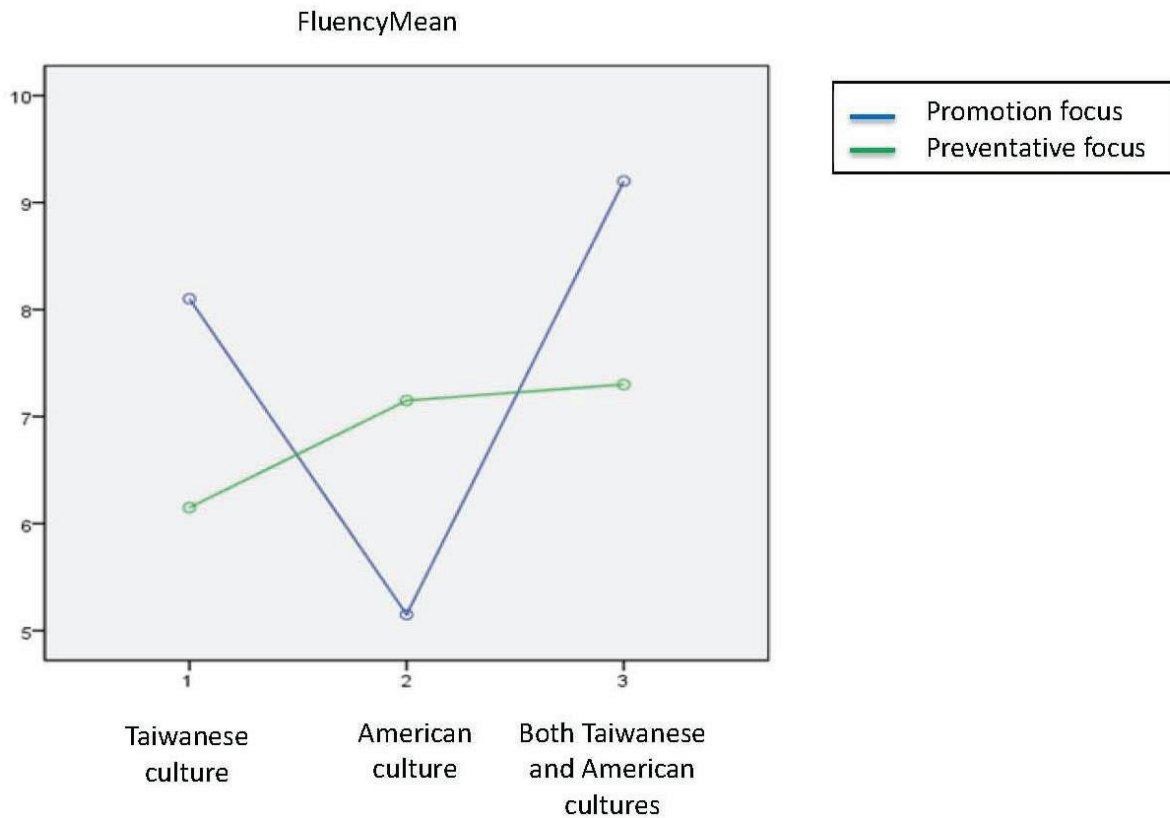
Fig. 5 Profile plots of interaction effects- fluency
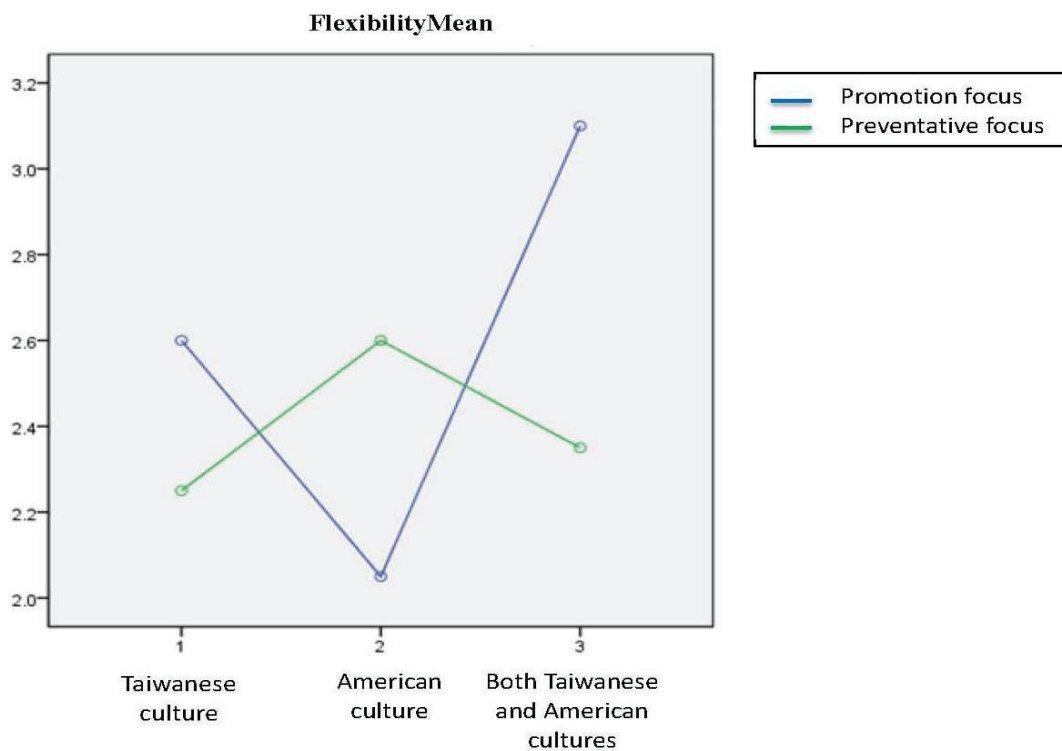
FlexibilityMean

Fig. 6 Profile plots of interaction effects- flexibility

The interaction effects were significant; therefore, the results were subjected to analysis of simple main effects. The results show significant differences in multicultural experience under a promotion focus (fluency: $F(2,114)=83.96$, $p<0.05$, post hoc test 3>1>2; flexibility: $F(2,114)=16.08$, $p<0.05$, post hoc test 3>1>2) but no significant differences in multicultural experience under a prevention focus for flexibility (fluency: $F(2,114)=10.29$, $p<0.05$, post-hoc test 3>1>2; flexibility: $F(2,114)=2.17$, $p=0.12>0.05$, n.s.). In contrast, significant differences were found in regulatory focus for Taiwanese culture alone (fluency: $F(1,114)=39.75$, $p<0.05$; flexibility: $F(1,114)=4.41$, $p=0.042<0.05$), American culture alone (fluency: $F(1,114)=48.88$, $p>0.05$; flexibility: $F(1,114)=8.36$, $p=0.006<0.05$), and both Taiwanese and American cultures (fluency: $F(1,114)=38.75$, $p<0.05$; flexibility: $F(1,114)=17.31$, $p<0.05$).

DISCUSSION

The results of our experiment demonstrate that in circumstances with a focus on either promotion or prevention, scenarios involving multicultural experience (both Taiwanese and American cultures) proved more effective in promoting creativity than scenarios involving Taiwanese or American culture alone. Therefore, H1 is supported. For Taiwanese culture alone, a focus on promotion proved more effective in promoting creativity than a focus on prevention. In contrast, for American culture alone, a focus on prevention proved more effective in promoting creativity than a focus on promotion. With regard to multicultural experiences, a focus on promotion proves more effective than a focus on prevention in the promotion of creativity.

The results of two-way ANOVA demonstrate that the main effects of the two independent variables (multicultural experience and regulatory focus) reached the level of significance. Moreover, their interaction effects were significant. Thus, we conducted a simple analysis of the main effects, the results of which indicate significant differences in multicultural experience in terms of promotion focus but not in terms of prevention focus. Regulatory focus also prevented significant differences under the stimulus of Taiwanese culture only and both Taiwanese and American culture; however, this effect was not observed for American culture only. The interaction effects between multicultural experience and regulatory focus indeed influenced personal creativity; therefore, H2 is supported. In addition, promotional motivation strengthened the influence of multicultural experience on creativity, whereas preventative motivation weakened the influence of multicultural experience on creativity.

CONCLUSION

Theory and Managerial Implications

Our research demonstrates that the relationship between creativity and the interaction effects of multicultural experience and regulatory focus. This contribution to understanding the influence of creativity extends theory on multicultural experience, regulatory focus, and

creativity; moreover, it affirms the human resource management practices of the organizations that seek out, promote, and develop multicultural experience. There are two important managerial implications from this study. First, we suggest that organizations provide and design an interactive environment with multicultural experience while encouraging a focus on promotion; they could enhance the creative performance of their personnel. In the workplace, organizations could arrange trips or implement job rotation programs with other countries to enable employees to engage in cultural exchange. Additionally, integration of employees from different backgrounds in the same team or department to provide work experience in a multicultural environment that can potentially inspire people more facile at creative problem solving and idea generation. We suggest organizations can design both cultural competence and creativity training programs and supplemented by promotion focus motivation and goals setting to enhance the creativity performance of employees. These efforts, in conjunction with a focus on promotion (setting goals), could improve the creativity of employees. Second, our research also has significant implications for education. Leung, Maddux, Galinsky, & Chiu (2008) demonstrate to educators and practitioners the positive aspects of cultural diversity that can benefit every student, thus giving students from diverse ethnic and cultural backgrounds the confidence and motivation to learn in a multicultural education setting. We suggest that schoolteachers could make use of study abroad programs and set goals with encouraging a focus on promotion to enhance creativity. The same is true for students who study abroad and for employees who are sent to work or receive training in foreign branches.

Limitations and Future Research

These results must be considered in light of several study limitations. We also want to acknowledge the limitations of the research reviewed above and their implications for future research directions. First, experimental studies allowed us to draw conclusions about the causal relationships. However, the field studies within organizational settings provided increased external validity. Thus, we suggest that used a combination of both experimental and field studies to address our research question. Second, the present paper priming the regulatory focus but did not control for some personality factors previously shown to be associated with creativity (e.g., risk-taking, ambition, confidence, and intrinsic motivation; Simonton, 2000). Future research should ensure that nonexperimental, correlational studies control for the full range of personality variables previously found to be associated with creativity. A third potential limitation was related to external validity. The study sample was limited to a single country Taiwan in a single culture, had a relatively homogenous sample could be considered a weakness about the generalizability of our findings to other types of employees, organizations, or national contexts. We encourage researchers to conduct similar studies with more diverse samples and/or in other national contexts and to explore the possibility of cultural differences in interaction between regulatory focus and multicultural experience impact creativity.

REFERENCE

1. Amabile, T.M.(1983), "The social psychology of creativity: A componential conceptualization", *Journal of Personality and Social Psychology*, Vol. 45, pp. 357-376.

2. Barsalou, L. W. (1985), "Ideals, central tendency, and frequency of instantiation as determinants of graded structure in categories", *Journal of Experimental Psychology: Learning, Memory, and Cognition*, Vol. 11 No. 4, pp. 629-654.

3. Battig, W. F., and Montague, W. E. (1969), "Category norms of verbal items in 56 categories A replication and extension of the Connecticut category norms", *Journal of Experimental Psychology Monographs*, Vol. 80 No. 3, pp. 1-46.

4. Cheng, C. Y., Leung, A. K., and Wu, T.Y. (2011), "Going Beyond the Multicultural Experience—Creativity Link: The Mediating Role of Emotions", *Journal of Social Issues*, Vol. 67 No. 4, pp. 806-824.

5. Cheng, C. Y., Sanchez-Burks, J., and Lee, F. (2008), "Connecting the Dots Within: Creative Performance and Identity Integration", *Psychological Science*, Vol. 19 No. 11, pp. 1178-1184.

6. Finke, R. A., Ward, T. B., and Smith, S. M. . (1992), *Creative cognition: Theory, research, and applications*, Cambridge, MA: MIT Press.

7. Forster, J., Friedman, R. S., and Liberman, N. (2004), "Temporal construal effects on abstract and concrete thinking: consequences for insight and creative cognition", *Journal of Personality and Social Psychology*, Vol. 87 No. 2, pp.177-189.

8. Friedman, R. S., and Forster, J. (2001), "The effects of promotion and prevention cues on creativity", *Journal of Personality and Social Psychology*, Vol. 81 No. 6, pp. 1001-1013.

9. Gordon, M. E., Slade, L. A., and Schmitt, N. (1986), "The ''science of the sophomore'' revisited: from conjecture to empiricism", *Academy of Management Review*, Vol. 11, pp. 191–297.

10. Gordon, M. E., Slade, L. A., and Schmitt, N. (1987), "Student guinea pigs: porcine predictors and particularistic phenomena", *Academy of Management Review*, Vol. 12, pp. 160–163.

11. Guilford, J. P. (1950), "Creativity", *The American Psychologist*, Vol.5, pp.444-454.

12. Guilford, J. P. (1959), "Traits of Creativity", in H. H. Anderson (Ed.), *Creativity and its cultivation*. New York: Harper.

13. Higgins, E. T. (1997), "Beyond pleasure and pain", *American Psychologist,* Vol. 52, pp. 1280-1300.

14. Hirt, E. R., Devers, E. E., and McCrea, S. M. (2008), "I want to be creative: exploring the role of hedonic contingency theory in the positive mood-cognitive flexibility link", *Journal of Personality and Social Psychology*, Vol. 94 No. 2, pp. 214-230.

15. Leung, A. K., and Chiu, C. Y. (2010), "Multicultural Experience, Idea Receptiveness, and Creativity", *Journal of Cross-Cultural Psychology*, Vol. 41 No. 5-6, pp.723-741.

16. Leung, A. K., Maddux, W. W., Galinsky, A. D., and Chiu, C. Y. (2008), "Multicultural Experience Enhances Creativity:The When and How", *American Psychologist*, Vol. 63 No. 3, pp. 169-181.

17. Maddux, W. W., and Galinsky, A. D. (2009), "Cultural borders and mental barriers: The relationship between living abroad and creativity", *Journal of Personality and Social Psychology*, Vol. 96 No. 5, pp. 1047-1061.

18. Mumford, M. D., and Gustafson, S. B. (1988), "Creativity syndrome: Integration, application, and innovation", *Psychological Bulletin*, Vol. 103, pp. 27-43.

19. Paulus, P.B., and Nijstad, B.A. (2003), *Group creativity: Innovation through collaboration* , New York: Oxford University Press.

20. Seibt, B., and Forster, J. (2004), "Stereotype threat and performance: how self-stereotypes influence processing by inducing regulatory foci", *Journal of Personality and Social Psychology*, Vol. 87 No. 1, pp. 38-56.

21. Simonton, D. K. (2000), "Creativity: Cognitive, personal, developmental, and social aspects", *American Psychologist*, Vol. 55 No. 1, pp. 151–158.

22. Spiro, R.J., Vispoel, W. L., Schmitz, J., Samarapungavan, A., and Boerger, A. (1987), *Knowledge Acquisition for Application:Cognitive Flexibility and Transfer in Complex Content Domains.* in B. C. Britton & S. Glynn (Eds.). Hillsdale, NJ: Lawrence Erlbaum Associates.

23. Wan, W. N., and Chiu, C. Y. (2002), "Effects of Novel Conceptual Combination on Creativity", *The Journal of Creative Behavior*, Vol. 36 No. 4, pp. 227-240.

24. Ward, T. B., Patterson, M. J., Sifonis, C. M., Dodds, R. A., and Saunders, K. N. (2002), "The role of graded category structure in imaginative thought", *Memory and Cognition*, Vol. 30 No. 2, pp. 199-216.

A DELIBERATIVE CONCEPTION OF ADJUSTED EXPECTATIONS: EDT AND VALUE CONCEPT

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ABSTRACT

Adjusted expectations are useful way of understanding post-purchase satisfaction and explaining the change of individual-level expectations, yet research has yet to fully explain what factors influence for predicting customer's adjusted expectations in the specific online store. This study aims to explore adjusted expectations within the context of expectancy disconfirmation theory and the value concept to gain insight into effective strategies to manage changing customer expectations. An empirical study was conduct to compare the underlying EDT variables and the value concept variables link to adjusted expectations. The target population of this study is general Taiwanese online customers who have made online purchases of products or services in the past. The results show that perceived performance, disconfirmation and customer satisfaction of membership EDT, and confidence benefits and perceived value members in the value concept appear to be positive effect on adjusted expectations. The results imply that all factors in EDT integrate to the value concept can be as an assessment of adjusted expectations. The present findings contribute to the field's understanding of the various forces acting on adjusted expectations in online shopping context through the lens of cognitive-affective dimensions in EDT and customer gains in value concept.

Keywords: Adjusted expectations, Expectancy disconfirmation theory, Value concept

Paper type: Research paper

INTRODUCTION

Adjusted expectations have used to be a mechanism for guiding and predicting the purchase behavior in the next period and useful for explaining the changing of individual-level expectations (Yi and La, 2004). When e-vendors consider the customer expectations after the product/service has been provided, what is actually being used is another type of expectations, known as adjusted expectations or adaptive expectations (Rufín et al., 2012). This reflects the centrality of products and services in post-consumption, and the importance of value

decisions with the repurchase intentions. Nevertheless, relatively little research attention so far seems to have been devoted to a consideration of the factors of adjusted expectations in the context of online business. As online markets have become increasingly competitive, online customers have become more demanding, expecting increasingly diverse categories of products or services to be provided to satisfy their needs. Furthermore, the online channel is also associated with greater convenience, competitive prices and time saving; there are inevitably implications for how online customers adjust their expectations. Given that a consequence of the post-repurchase satisfaction, determining adjusted expectations have become even more complex.

This study proposes and investigates a research model of adjusted expectation using consumer data from the online markets in Taiwan. The study takes two comprehensive views of expectancy disconfirmation theory (EDT) and the value concept, synthesizing research from psychology, economic and marketing. The goal is to conceptualize the adjusted expectations model through the impact of factors in EDT and the value concept on adjusted expectations in online shopping context. This is done with the hope that it may contribute the important information for the market decision-making of the e-vendors. Additionally, examining how the revision of customer expectations may serve e-vendors with insights to develop effective strategies to manage changing customer expectations.

THEORETICAL BACKGROUND AND HYPOTHESES

The diffusion of online marketing, increasing diversity of products and services, the revision of customer expectations issue associated with online shopping add to its complexity. An online business has a limitation in physical examination might lead to customer uncertainty in purchase decision, this issue could lead to psychological and economic concerns for online customers. In order to understand the important antecedents of adjusted expectations via both two concepts along with studying how their relative weight changes as an influence on adjusted expectations at the online store. Fig.1 displays the research model. Paths based on relationship between factors of both EDT and the value concept and adjusted expectations are presented with simple arrows.
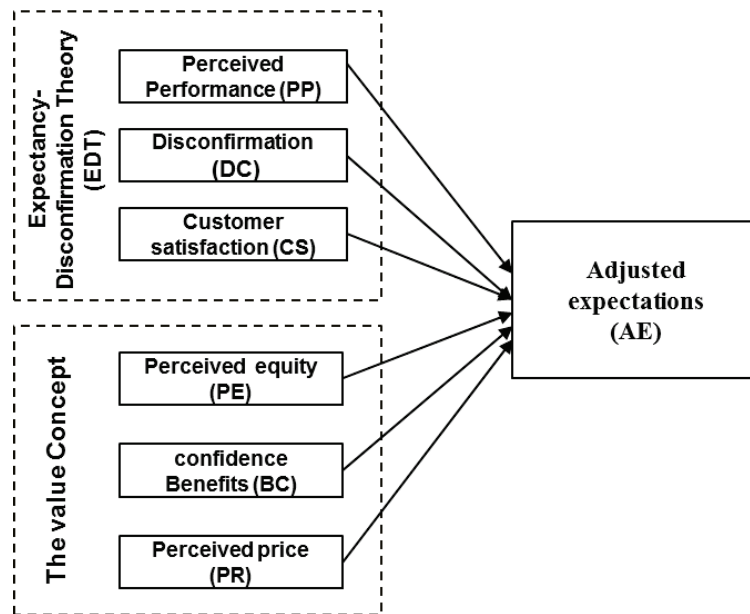
Fig. 1. Research model

adjusted expectations

The changing of customer expectations is as cognitive judgment process after post-purchase experience (Ha et al., 2010). Pre-purchase stage customer expectations are belief probabilities of product/service delivery which serve as a standard against the actual performance (Oliver, 1980). When after the product/service has been provided, expectations updated through cumulated or current consumption experiences, customer expectation what is actually being used is another type of expectations, known as adjusted or adaptive expectations (Rufín et al., 2012). Moreover, as post hoc expectations after the consumption experience, adjusted expectations will reflect purchase behavior in the next period (Yi and La, 2004). In the context of online business, adjusted expectations may possibly act as a tool for predicting repurchases behavior in the specific online store (Ha et al., 2010). Prior research suggests that adjusted expectations are useful way of understanding post-purchase satisfaction and explaining the change of individual-level expectations (Rufín et al., 2012). Given that marketers and retailers would like to have control over customer expectations, but customers hold different level of expectations about product/service.

EDT and online shopping

Knowing adjusted expectations is important for online retailers to satisfy customer in the next purchasing. Yi and La (2004) have pointed out that adjusted expectations have a role to predict repurchase behavior in the future and serve as anchor in evaluating future customer satisfaction. Adjusted expectations are another type of expectations which adapt from prior expectations in pre-purchase. In online business, customers' intentions to repurchase a product/service or continue service use is determined primarily by their confirmed expectations which are related to EDT as a cognitive process of post-customer satisfaction (Ha et al., 2010). Thus, using EDT as a theoretical lens, it can be reasonably inferred that

customer expectations and may determine customer behavior and attitudes toward adjusted expectations.

Perceived performance

Perceived performance has been developed with the customers' experience of using product/service vis-à-vis their initial expectations that can be better or worse than initial expectations. After using product or service, customers form perception about their actual performance. When actual performance can exceed customer expectations, it will be effect on customer satisfaction and likely to adjust their expectations, which are consequence of a customer satisfaction (Ha et al., 2010). Therefore, perceived performance may impact on adjusted expectations in post-consumption. Thus, we predict:

H1: Perceived performance positively influences adjusted expectations.

Disconfirmation

In EDT, disconfirmation is defined as the difference between initial expectations and perceived performance. When the quality of product/service performs better than expected, consequently, the impact of disconfirmation on customer satisfaction will be higher, customer satisfaction will, in turn, influence adjusted expectations (Rufín et al., 2012). In sum, disconfirmation may tend to adjust customer expectations in post-consumption. Thus, we predict:

H2: Disconfirmation positively influences adjusted expectations

Customer satisfaction

The role of satisfaction is a respond that occurs when customers experience a pleasure level of consumption-related fulfillment when evaluating a product or service (Oliver, 1981). Customer satisfaction is also a resulting from cognitive appraisal of the difference between initial expectations and actual performance. More specially, in recent studies show that customer satisfaction judgment in a repurchase behavior is updated spontaneously when customers are faced with an expected consumption experience. When a customer experiences good feeling and positively experience at the online store, the customer will be willing to repurchase at the online store. More specially, the satisfied customers with positively experience will affect the higher their expectations are adjusted. Therefore resulting level of customer satisfaction is major influence on repurchase expectations (Ha et al., 2010). Thus, we predict.

H3: Customer satisfaction positively influences adjusted expectations.

The value concept and online shopping

In the context of online business, value has been considered as the concept to the long-term successful and one of the powerful force in today's marketplace (Kim et al., 2013). This

ability has become a key to the challenge of how to grasp a sustainable competitive advantage. In the process of the making decision, customers are expected to analyze various characteristics of the services, including the cost and benefits that they are likely to encounter before and after using the service (Barclay et al., 1995). Given that customer-perceived value is associated with greater confidence benefits, perceived price and perceived equity, there are inevitably implications for how customers evaluate perceived value.

Perceived equity

The concept of equity is a key psychological reaction and brings together the value concept that a service company provides (Olsen and Johnson, 2003, Kazemi et al., 2013). Perceived equity is conceptualized as the fair treatment received by customers from the service providers they bought their products/services from (Musa et al., 2005). In fact, it is intuitively reasonable to believe that customers who receive that they have received great value from the product/service consumption experiences will also feel they have been treated equitably by the seller (Oliver and Swan, 1989). In context of online business, perceived equity is not only a key component in signifying whether or not and exchange is fair (Gassenheimer et al., 1998), but also effect on the changing in customer expectations into the realistic expectations for the next purchasing (Ramaseshan et al., 2013). Hence, we assert that adjusted expectations are a consequence of customer's perception of equity in the vendor. We propose the following.

H4: Perceived equity positively influences adjusted expectations.

Confidence benefits

The perception of confidence benefits in online transaction is an important indicator for the online customer loyalty development (Yen and Gwinner, 2003). Confidence benefits describe the reduction of uncertainty in transaction and increase realistic expectations regarding beneficial conduct of the online store, characterized as reliance, trust, and assurance. (Chang and Fang, 2013, Yen and Gwinner, 2003). As much of the emerging self-service technology, the importance of Internet based self-service applications may influence in confidence and special treatment benefits, evidence in support of that is the online store's relationship quality with it customer by given security and privacy (Dimoka, 2010, Zhang et al., 2011). Furthermore, prior research suggests that confidence benefits are primary concerned for repurchase intention through customer satisfaction (Yen and Gwinner, 2003). The online customer represents a belief that better outcomes will tend to heighten repurchase expectations. Based on the suggestions in the literature; this study proposes that confidence benefits have a positive impact on adjusted expectations. We predict.

H5: Confidence benefits positively influence adjusted expectations.

Perceived price

Perceived price is currently one of the intriguing factors for online customers to evaluate quality. It can be conceptualized as involving overall assessment on the product/service utility determines by customer's perception of what is received (benefits) and what is give (cost)(Zeithaml, 1988). Previous research suggests that perceived price is something that must be given up or sacrificed to obtain certain kinds of products or services (Iveroth et al., 2013). In regards to the online shopping environment, customers who perceived a price as unfair experience negative attitudes toward the provider, and engage in revenge-seeking behavior such as switching to another competitors (Ferguson, 2014). In addition, Customers basically have adjusted expectations whenever the undertaken a particular service to satisfy their needs, so they expect that the product/service will generate value for their money and it will perform in accordance to their expectations (Cook et al., 1979). Therefore, this study proposes that perceived value has a positive impact on adjusted expectations. We predict.

H6: Perceived price positively influences adjusted expectations.

RESEARCH METHOD

At the purpose of this research is to investigate the antecedents of adjusted expectations, which tend to predict the repurchase behavior in online shopping. An empirical study was conduct to compare the underlying the constructs of EDT and the value concept link to adjusted expectations. The target population of this study is general Taiwanese customers who have made online purchases of products or services in the past. By definition, the products or services include cloth, books, electronic goods, any of online service such as airline ticket booking, hotel reservation. In other words, anyone purchasing product/service online in the past is a potential member of the target population in this study. In the current research conducted a two-stage study of empirically examine the validity of the proposed model. The first survey was aimed at testing links explaining earlier post-consumption beliefs for consumers, while the second one focused on links explaining later post-consumption variables.

Participants

Information provided by 204 respondents on their Internet usage and online shopping behavior revealed that they were experienced online shopping consumer. The male/female ratio of the respondents was 33% and 67%, respectively, and the respondents tend be younger than 35 years old and well-educated (70% had undergraduate degree and 30 % had postgraduate degree). The responses to the frequency of online shopping were as follows: less than once a month (29%), a few times a month (62%), a few times a week (7%), and about once a day (2%).

Measurement

Wherever possible, we draw on the existing literature and adapt existing instruments for measuring the variables in our study. The other items are adapted from studies which

measured the quality of constructs in various contexts. The variables were measured with seven-point Likert scale (1= strongly disagree, 2 = disagree, 3 = slightly disagree, 4 = neutral, 5 = slightly agree, 6 = agree, 7 = strongly agree).

Table 1. Constructs and measurements

Constructs	Number of items	Measurement sources (adapted)
Initial expectations	3	Khalifa (2004) and Bhattacherjee (2001)
Perceived performance	4	Khalifa (2004) and Bhattacherjee (2001)
Disconfirmation	3	Bhattacherjee (2001)
Customer satisfaction	4	Wu (2012) and Bhattacherjee (2001b)
Perceived sacrifice	3	Teas and Agarwal (2000)
Perceived equity	3	Olsen and Johnson (2003)
Confidence benefits	4	Yen and Gwinner (2003)
Perceived price	3	Kim et al. (2012)
Adjusted expectations	3	Yi and La (2004)

RESULTS

The research models were analyzed using partial least square (PLS), with the use of SmartPLS 2.0. PLS is a structural equation model (SEM) approach and uses a component-based approach to estimation. Through its confirmatory factor analytical capability, PLS was used to assess both the psychometric properties of all scale and, subsequently, to test the structural relationships proposed in the model. Furthermore, PLS regression is a recent technique that generalizes and combines features from principal component analysis and multiple regressions. Its goal is to predict a set of dependent variables from a set of independent variables or predictors.

Data analysis of the measurement model
The psychometric properties of scale in PLS were assessed in terms of item loadings, discriminant validity, and internal consistency (reliability). Both item loading and internal consistencies greater than 0.70 are considered to be acceptable (Fornell and Larcker, 1981). As can been seen from the confirmatory factor analysis (CFA) results, all items loaded very well on their corresponding factors, Moreover, we carried out reliability assessment using Cronbach's alpha. The Cronbach's alpha coefficient for all constructs were all above 0.80, exceeding the minimum acceptable level of 0.70 (Nunnally, 2010), and the composite reliability scores shown in Table 2, all exceeded the 0.70 criterion (Barclay et al., 1995, Fornell and Larcker, 1981).

Table 2. Measurement model

Constructs/Indicators	Mean	SD	Loadings	t-value	Cronbach's Alpha	CR
Perceived Performance (PP)					**0.88**	**0.94**
PP01: Transaction processing was efficient.	5.55	1.04	0.908	53.61		
PP02: Transaction processing was convenient.	5.30	1.16	0.925	41.20		
PP03: The products offered were what I was seeking.	5.50	1.03	0.861	16.89		
Disconfirmation (DC)					**0.91**	**0.94**
DC01: The after-sale service was better than expected.	5.29	1.07	0.817	17.92		
DC02: Provide a better excellence deal than expected.	5.27	1.05	0.878	28.25		
DC03: Buying from this store was better decision than I anticipated.	5.47	1.00	0.943	93.78		
DC04: Overall, this online store was a more pleasing shopping experience than I expected.	5.47	1.01	0.926	69.30		
Customer Satisfaction (CS)					**0.97**	**0.97**
CS01: Satisfaction	5.59	0.98	0.944	78.21		
CS02: Please	5.57	0.99	0.956	108.22		
CS03: Content	5.61	1.02	0.947	69.99		
CS04: Delight	5.55	1.05	0.960	97.24		
Perceived Equity (PE):					**0.94**	**0.96**
PE01: Even if another online stores offer the same service, I would still prefer this online store.	5.36	1.17	0.959	96.51		
PE02: If another online stores offer the same service, I would prefer this online store.	5.30	1.24	0.949	39.27		
PE03: If another online store are not different from this online store in any way, it still seems smarter to purchase this online store.	5.43	1.13	0.934	53.07		
Confidence benefits (CB)					**0.94**	**0.96**
CB01: I have more confidence the service will be performed correctly.	5.48	1.09	0.944	75.28		
CB02: I believe there is less risk that something will go wrong.	5.46	1.12	0.943	72.98		
CB03: I feel I can trust this online store.	5.52	1.06	0.941	60.10		
Perceived price (PR)					**0.90**	**0.94**
PV01: This online store's services are reasonably priced.	5.06	1.04	0.890	37.29		
PV02: This online store offers good services for the price.	5.33	1.05	0.933	72.24		

Constructs/Indicators	Mean	SD	Loadings	t-value	Cronbach's Alpha	CR
PV03: This online store offers good value for the price I pay.	5.28	1.04	0.918	52.43		
Adjusted Expectations (AE)					**0.91**	**0.94**
AE01: I now expect this online store will provide The after-sale service.	5.37	1.05	0.846	26.95		
AE02: I now expect that purchasing from this online store will provide an excellent deal.	5.34	1.01	0.846	22.51		
AE03: I now expect that purchasing from this online store will be a good decision.	5.51	0.99	0.940	75.48		
AE04: I now expect this online store will be an overall pleasing shopping experience.	5.56	0.98	0.937	75.13		

Discriminant validity is demonstrated in PLS when indicators load higher on their corresponding construct than on other constructs in the model, and the square root of the average variance extracted (AVE) for each construct is larger than its correlations with other constructs. As shown in Table 3, all indicators loaded more highly on their own construct than on other constructs. Furthermore, comparing the inter-construct correlations and square root of AVE (leading diagonal) reveal that all constructs share considerably more variance with their indicators than with other constructs (Chin, 1998). Thus these results point to the discriminant validity of our scales.

Table 3: Correlation of latent variables

	AVE	PP	DS	CS	PE	CB	PV	AE
PP	0.808	*0.899*						
DS	0.796	0.797	*0.892*					
CS	0.906	0.754	0.839	*0.952*				
PE	0.897	0.709	0.790	0.802	*0.947*			
CB	0.889	0.778	0.817	0.860	0.842	*0.943*		
PV	0.835	0.740	0.814	0.806	0.726	0.733	*0.914*	
AE	0.798	0.825	0.880	0.864	0.787	0.858	0.828	*0.893*

The bold numbers on the leading diagonal are the square root of the variance shared between the constructs and their measure. Off diagonal elements are the correlations among constructs. For discriminant validity, diagonal elements should be greater than off diagonal elements.

Hypothesis testing

PLS was also used to test the structural model. Path coefficients and explained variances for the research model of the study are shown in Fig. 2. The constructs of EDT and the value concept explained 87.0 % of the variation in adjusted expectations.
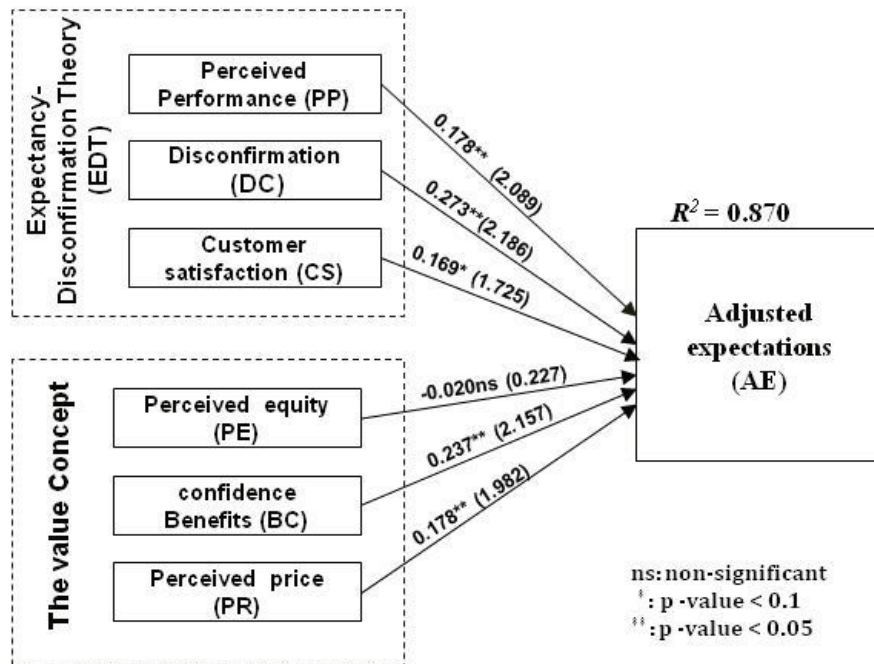
Fig. 2. Results of the structural models

Considering factors of EDT, the analysis shows that perceived performance was positively related to adjusted expectations ($\beta = 0.178$, $t = 2.089$), thus H1 was supported. Disconfirmation appeared a strong predictor of adjusted expectations ($\beta = 0.273$, $t = 2.186$), which support H2. In addition, Customer satisfaction positively influenced on adjusted expectations ($\beta = 0.169$, $t = 1.715$), thus H3 was supported. In the view of the value concept, the analysis shows that perceived equity was not significant to adjusted expectations ($\beta = -0.020$, $t = 0.0227$), thus H4 was not supported. Confidence benefits were significant to adjusted expectations ($\beta = 0.237$, $t = 2.157$), thus H5 was supported. Finally, perceived price has a positive effect on adjusted expectations ($\beta = 0.178$, $t = 1.982$), thus H6 was supported.

DISCUSSION OF FINDINGS

A basic understanding obtained from this study is the abundance and significance of relationships between adjusted expectations and its existing antecedents. This study proposes research model that integrates, factors of EDT and the value concept to explain adjusted expectations in online business context. The results imply that all factors of EDT have a significant impact on adjusted expectations. Furthermore, the value concept effects in online customers are important drivers of adjusted expectations. Besides, perceived equity was found to be insignificant predictor of adjusted expectations. Therefore, these results can serve as a strong and robust yet more unified and parsimonious framework for the theoretical refinements offered in this study.

Expectations in online stores are emerging as an important aspect of online shopping adoption as an increasing number in customer engage in transactions over the web. However, for EDT components, one the most of interesting findings of this study is an increase in the positively disconfirmation significantly higher the possibility that adjusted expectations go upward in the next purchasing of online shopping. One possible reason for this is that post-consumption beliefs held by experienced online customers, which as repeat purchase customers are based primarily on actual experience and more readily accessible in memory, resulting in stronger beliefs and attitudes behavior tie (Anderson, 2003). Another finding is that, in a view of EDT, perceived performance is a significant impact on adjusted expectations for online customers. A partial explanation for this may lie the consistent with the relationship marketing literature, which emphasizes long-term relationship with consumers with the creations of value through technology (Kuan et al., 2008). Online stores rely on Internet technology that can properly and promptly answering customer inquiries and enable customer to define the quality of service they want and enhance value for customer in the long term. As a result, perceived performance exerts a greater influence on online customers who are likely return to the online store continually and tend to be heightening repurchase expectations in the future.

The empirical findings proving interesting insights, customer satisfaction of the online store appear to play an important role in determining adjusted expectations on the specific online store. These findings are entirely consistent with the study of Yi and La (2004) and Ha et al. (2010). The previous empirical studies have shown that adjusted expectations are evaluated by post-customer satisfaction, which is presumed to have the underlying positive disconfirmation. This disconfirmation can be related to the peculiarities of the online shopping experience, as the transaction is perceived as performance and usefulness (Ting et al., 2013, Chiu et al., 2013), in terms of product/service. Once customers have accumulated positive experience and are familiar with the online store, thus disconfirmation and satisfaction are important factors in determining adjusted expectations to repurchase intention in the online store.

One of the most interesting findings of this study is that the value concept is more salient to online stores. Online customers seemed to hold different attitudes about confidences and benefits of online shopping at different level of online shopping experience. We found a significant effect of confidence benefits and perceived price to adjusted expectations in online customers. These results may be explained by considering the uncertainty and trusted party. A closer look at the concept of confidence benefits and value suggest that reduction of uncertainty in transaction and increase trust regarding beneficial conduct of the online store. This is consistent with prior research that indicates that trust will dominate the influence on repeat purchase intention including heightens repurchase expectations (Chiu et al., 2012).

More specially, in the view of value concept found that perceived equity has a non-significant effect on adjusted expectations. The results suggest that there may be the vary

types of products/services that moderate the effects of the sacrifice cues. One explanation for these results is that, when compared to different products/service may be perceived by consumers to more widely available across online retail stores. These findings are in accord with the result of which previous studies which may be that the online store affects perceive value of product/service through more complex processes (Teas and Agarwal, 2000).

CONCLUSIONS AND IMPLICATIONS

From the research model, it is argued that adjusted expectations of online customers were largely driven by the both EDT and value concept. Online customers considered the view of EDT to a greater extent in revision of their customer expectations regarding the post-consumption. In fact disconfirmation has a strong impact on adjusted expectations which driving customer expectations upwards from their current expectations. The value concept is further co-created is a major concern for online stores, fundamental to competitiveness and adjustment customer expectations. Consequently, EDT and value concept provide valuable insight into the repurchase behavior from the online customers' perspective.

Theoretical implications
The present findings contribute to the field's understanding of the various forces acting on adjusted expectations in online shopping context through comparing the lens of EDT and the value concept. According to EDT, perceived performance, disconfirmation and customer satisfaction are three potentially important influences of adjusted expectations in online customers. The reason for these results is that past experiences and knowledge in online shopping which serve as cognitive element led to a widespread acceptance of online customers' adjusted expectation needs and influence impact emotion needs for online shopping environment.

In terms of emphasis value concept focused on adjusted expectations, this study also offers a conceptualization of value as 'customer gains' which are driven by variables such as confidence benefits and perceived price that are continually weighted against each other during everyday purchases. Evidence from this study supports that confidence benefits in a transaction with an online retailer can increase the trustworthiness, including perceived price which engages monetary savings from online transaction in online shopping. The findings also suggest that confidence benefits and perceived price have been specifically developed for customer value in online shopping business. A possible explanation for these results is that confidence benefits and perceived price are affected by both cognitive psychology and economic theory (Gallarza et al., 2011). Moreover, the customer value also has been a result of a cognitive comparing process, with cognitive evaluation occurring before the emotional response from which value-added satisfaction stem. Accordingly, the product/service must be able to satisfy the needs of the customer and provide benefits that make the perceived value to adopt (Ravald and Grönroos, 1996).

Managerial implications

These results may have several implications can be practically implemented for online vendors to ultimately survival. Online vendors should be aware that customer expectations are not only a dynamic, with ebbs and flows, but also important determinants of customer feeling and psychological state of the online customers. This may imply a need to exceed or better manage expectations what is offered or communicated to customers. Alternatively it may suggest a need to build relationship strategy in line with current customer value propositions. For example using social networking methods such as Facebook or Twitter, a social platform allows users to connect and interact with their personal and professional network. More specially, social networking can actually create value and increase feeling of confidence and trustworthiness for non-habitual online customers by way of comments and shares in social networking. Research recently suggests that comments and shares are the nature of customer feedback which reflects what customers trust brand recommendations and commenting about their great experience from friends.

Furthermore, consistent with the argument of social psychologist, customers are not just satisfied with the purchase but also feel good about the online store and its practices so that expectations can be enhanced, thus affecting the likelihood of adjusted expectations (Ha et al., 2010, Forgas and East, 2008). In order to establish a broad online marketing strategy that will effectively help online retailers to meet customer expectations and constantly innovate to find new sources of consumer value. An online store could consider creating a web store with a difference, learn about customers and create unique branding online store by attractive display of the online store. For instance, make "hot sellers" to attract a customer and advertise the products/services, including refresh online store's content and provide incentives for return visitors to the online store which could be used to encourage online customers do not forget the online store.

LIMITATIONS AND FUTURE RESEARCH

There are some limitations of survey research. First, although the result of descriptive analysis has shown the impact of EDT and value concept factors on adjusted expectations; therefore, other factors were not considered. Other factors, such as pricing, perceived behavioral control, also influence online customers' expectations. An interesting future research could examine the effects of pricing and perceived behavioral control on adjusted expectations.

Furthermore, the data for this study was collected from vary across online stores and categories of products/services of the respondents in this study. Since the quality of products/services varies across vendors and categories of products/services, the result may reflect in part the way in which the data were collected. It would be interesting direction for further research, to test the proposed hypotheses and compare them across search product categories as well as various online vendors.

REFERENCES

1. Anderson E. W. (2003), "The Formation of Market-Level Expectations and Its Covariates", *Journal of Consumer Research,* Vol. 30, No. 1, pp. 115-124.
2. Barclay D., Higgins, C. and Thompson, R. (1995), "The partial least squares (PLS) approach to causal modeling: personal computer adoption and use as an illustration", *Technology studies,* Vol. 2, No. 2, pp. 285-309.
3. Bhattacherjee A. (2001), "Understanding information systems continuance: An expectation-confirmation model", *MIS Quarterly,* Vol. 25, No. 3, pp. 351-370.
4. Chang Y.-S. and Fang, S.-R. (2013), "Antecedents and distinctions between online trust and distrust: Predicting high-and low-risk internet behaviors", *Journal of Electronic Commerce Research,* Vol. 14, No. 2, pp. 149-166.
5. Chin W. W. (1998), "Commentary: Issues and opinion on structural equation modeling", *MIS Quarterly,* Vol. 22, No. 1, pp. 7-16.
6. Chiu C. M., Hsu, M. H., Lai, H. and Chang, C. M. (2012), "Re-examining the influence of trust on online repeat purchase intention: The moderating role of habit and its antecedents", *Decision Support Systems,* Vol. 53, No. 4, pp. 835-845.
7. Chiu S. P., Chuang, L. W. and Hsu, M. H. (2013), "Perceived quality, perceived value and repurchase decision in online shopping context", *Applied Mechanics and Materials,* Vol. 311, No. pp. 43-48.
8. Cook T. D., Campbell, D. T. and Day, A. (1979), *Quasi-experimentation: Design & analysis issues for field settings*, Houghton Mifflin Boston.
9. Dimoka A. (2010), "What does the brain tell us about trust and distrust? Evidence from a functional neuroimaging study", *Mis Quarterly,* Vol. 34, No. 2, pp. 373-396.
10. Ferguson J. L. (2014), "Implementing price increases in turbulent economies: Pricing approaches for reducing perceptions of price unfairness", *Journal of Business Research,* Vol. 67, No. 1, pp. 2732-2737.
11. Forgas J. P. and East, R. (2008), "On being happy and gullible: Mood effects on skepticism and the detection of deception", *Journal of Experimental Social Psychology,* Vol. 44, No. 5, pp. 1362-1367.
12. Fornell C. and Larcker, D. F. (1981), "Evaluating structural equation models with unobservable variables and measurement error", *Journal of Marketing Research,* Vol. 18, No. 1, pp. 39-50.
13. Gallarza M. G., Gil-Saura, I. and Holbrook, M. B. (2011), "The value of value: further excursions on the meaning and role of customer value", *Journal of Consumer Behaviour,* Vol. 10, No. 4, pp. 179-191.
14. Gassenheimer J. B., Houston, F. S. and Davis, J. C. (1998), "The role of economic value, social value, and perceptions of fairness in interorganizational relationship retention decisions", *Journal of the Academy of Marketing Science,* Vol. 26, No. 4, pp. 322-337.
15. Ha H. Y., Janda, S. and Muthaly, S. K. (2010), "A new understanding of satisfaction model in e-re-purchase situation", *European Journal of Marketing,* Vol. 44, No. 7/8, pp. 997-1016.

16. Iveroth E., Westelius, A., Petri, C.-J., Olve, N.-G., Cöster, M. and Nilsson, F. (2013), "How to differentiate by price: Proposal for a five-dimensional model", *European Management Journal,* Vol. 31, No. 2, pp. 109-123.

17. Kazemi A., Abadi, H. R. D. and Kabiry, N. (2013), "Analyzing the Effect of Customer Equity on Repurchase Intentions", *International Journal of Academic Research in Business and Social Sciences,* Vol. 3, No. 6, pp. 78-92.

18. Khalifa A. S. (2004), "Customer value: A review of recent literature and an integrative configuration", *Management decision,* Vol. 42, No. 5, pp. 645-666.

19. Kim H.-W., Xu, Y. and Gupta, S. (2012), "Which is more important in Internet shopping, perceived price or trust?", *Electronic Commerce Research and Applications,* Vol. 11, No. 3, pp. 241-252.

20. Kuan H.-H., Bock, G.-W. and Vathanophas, V. (2008), "Comparing the effects of website quality on customer initial purchase and continued purchase at e-commerce websites", *Behaviour & Information Technology,* Vol. 27, No. 1, pp. 3-16.

21. Musa R., Pallister, J. and Robson, M. (2005), "The roles of perceived value, perceived equity and relational commitment in a disconfirmation paradigm framework: An initial assessment in a relationship-rich'consumption environment", *Advances in Consumer Research,* Vol. 32, No. 1, pp. 349-357.

22. Nunnally J. C. (2010), *Psychometric Theory 3E*, Tata McGraw-Hill Education.

23. Oliver R. L. (1980), "A cognitive model of the antecedents and consequences of satisfaction decisions", *Journal of marketing research,* Vol. 17, No. 4, pp. 460-469.

24. Oliver R. L. (1981), "Measurement and evaluation of satisfaction processes in retail settings", *Journal of retailing,* Vol. 57, No. 3, pp. 25-48.

25. Oliver R. L. and Swan, J. E. (1989), "Consumer perceptions of interpersonal equity and satisfaction in transactions: a field survey approach", *The Journal of Marketing,* Vol. 53, No. 2, pp. 21-35.

26. Olsen L. L. and Johnson, M. D. (2003), "Service equity, satisfaction, and loyalty: from transaction-specific to cumulative evaluations", *Journal of Service Research,* Vol. 5, No. 3, pp. 184-195.

27. Ramaseshan B., Rabbanee, F. K. and Hui, L. T. H. (2013), "Effects of customer equity drivers on customer loyalty in B2B context", *Journal of Business & Industrial Marketing,* Vol. 28, No. 4, pp. 335-346.

28. Rufín R., Medina, C. and Rey, M. (2012), "Adjusted expectations, satisfaction and loyalty development", *The Service Industries Journal,* Vol. 32, No. 14, pp. 2185-2202.

29. Teas R. K. and Agarwal, S. (2000), "The effects of extrinsic product cues on consumers' perceptions of quality, sacrifice, and value", *Journal of the Academy of marketing Science,* Vol. 28, No. 2, pp. 278-290.

30. Ting C.-W., Chen, M.-S. and Lee, C.-L. (2013), "E-satisfaction and post-purchase behaviour of online travel product shopping", *Journal of Statistics and Management Systems,* Vol. 16, No. 2-3, pp. 223-240.

31. Wu I.-L. (2012), "The antecedents of customer satisfaction and its link to complaint intentions in online shopping: An integration of justice, technology, and trust", *International Journal of Information Management,* Vol. 33, No. 1, pp. 166-176.

32. Yen H. J. R. and Gwinner, K. P. (2003), "Internet retail customer loyalty: The mediating role of relational benefits", *International Journal of Service Industry Management,* Vol. 14, No. 5, pp. 483-500.

33. Yi Y. J. and La, S. (2004), "What influences the relationship between customer satisfaction and repurchase intention? Investigating the effects of adjusted expectations and customer loyalty", *Psychology & Marketing,* Vol. 21, No. 5, pp. 351-373.

34. Zeithaml V. A. (1988), "Consumer perceptions of price, quality, and value: a means-end model and synthesis of evidence", *The Journal of Marketing,* Vol. 52, No. 3, pp. 2-22.

35. Zhang Y., Fang, Y., Wei, K.-K., Ramsey, E., Mccole, P. and Chen, H. (2011), "Repurchase intention in B2C e-commerce—A relationship quality perspective", *Information & Management,* Vol. 48, No. 6, pp. 192-200.

INCUBATION PERFORMANCE OF A SCIENCE PARK: CHANGE OF SELF-EFFICACY OF THE IN-PARK FIRMS

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ABSTRACT

Technological innovation is widely regarded as a key driver of economic growth in many advanced countries. Science parks are organizations managed by specialized professionals to promote and incubate technological innovations. To understand the performance of a science park in the pursuit of such a goal, we developed a scale, the "change of self-efficacy," based on the conventional self-efficacy theory to evaluate improvement in the competence of in-park firms after they have become members of the science park for a certain period of time. To test this scale as well as to analyze its potential impacts, we conducted a questionnaire survey with 89 in-park firms in Hong Kong. After an intensive statistical data analysis, we found that the measurement model of the scale of "change of self-efficacy" is acceptable in terms of both convergent and discriminant validity. Results further show that such a scale has significant impacts on perceived usefulness of the service, overall satisfaction with the service, confirmation of a user's initial expectation, and in turn the intention to continue using the service provided by the science park. This study extends the knowledge of self-efficacy, service quality, and expectation-confirmation and provides additional insights for providers of knowledge-intensive services to enhance user satisfaction and acceptance as well as to implement knowledge management successfully.

Keyword: Science park, self-efficacy, knowledge intensive service

EVALUATING FIRM PERFORMANCE OF VIETNAMESE BANKS WITH THE BALANCED SCORECARD

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ABSTRACT

In the global financial crisis conditions, Vietnam banking sector has suffered from liquidity and deadlock in the operation. Indispensably, evaluation and measurement of performance are an important task for the banks as well as has become a pressing, but many managers agree that their evaluation systems do not adequately fulfill this function. Actually, balanced scorecard (BSC) is a new idea in performance management and applies to evaluate firm or bank performance through finance and non- financial dimensions.

The purpose of this study is to determine the factors of BSC actually affecting Vietnamese banks. Besides, to test and generate model which is the best fit model used for the application and implementation BSC. Another purposed of study is to contribute to the understanding of how BSC is developed and applied in evaluating the performance of banks in Vietnam. Based on data declare available from the banks, stock market for the financial dimension and survey for non-financial dimension. BSC is derived to evaluating and measuring the performance of the banks in 2011. In the indefectible combination, Structural Equation Modeling (SEM) is employed to test relationships of BSC and firm performance of Vietnamese banks and adopted to verify the goodness of fit effects of measurement model and structural model. The results also indicate that BSC directly and positively influence firm performance of Vietnamese banks. Furthermore, due to lack of research work in this area and the banking sector in Vietnam, this study contributes to the knowledge on how Vietnamese banks may apply the BSC to evaluate their performance and management system. The author proposes some future research needs required in this area.

Keywords: balanced scorecard, firm performance, performance evaluation, bank, structural equation modeling.

INTRODUCTION

In 2011, the panorama of the world economy with the basic characteristics includes slow growth, unbalanced and always unstable. The economy of Vietnam cannot avoid the low growth status and the high inflation. In early 2011, the State Bank of Vietnam administered the monetary policy with a focus target of restraining the inflation. Though some outstanding results such as (1) the increase in credit and target achievement of the total payments, (2) the better orientation of the credit line in the area of rural agricultural production, medium and small businesses as well as the production of export goods, (3) the improvement of the execution of the commercial banks as well as the enhancement of the bank's financing market. There are still some inherent shortcomings of the operation in the banking sector in Vietnam. The main shortcomings of the operation in the Vietnamese Commercial Bank include the low growth rates of total assets; the difficulty in raising capital and liquidity which became a deep concern; the low profitability of the commercial banking system. The growth rate of total assets and credit in the commercial banks is declined compared to the previous year. In the context of the recession economic and the pessimistic forecasts about the prospects for recovery, the decline of the demand for business loans of businesses and consumer loans of individuals is found as an important cause. Besides, the high interest rate of about 25 percent per year exceeding the tolerance of the client also greatly contributed to the decline of the growth rate of total assets and credit.

The rapid development of Vietnam's banking system is the cause to the establishment the series of the new bank branch. The international economic integration brings not only opportunities but also challenges to the banking system in terms of bankruptcy, severe competition, and decrease in the market share. Therefore, evaluating the operation of the credit institutions and providing the promptly appropriate solutions is not only required by the managers and the supervisory authorities of the State Bank, but also extremely important for analysts, business partners and investors. In the past few decades, evaluating and measuring the performance is an important task for a bank as well as has become a hot topic, and has witnessed continuous development and modifications by academicians and practitioners. The reason of the interest in this topic is triggered by the growing criticism of financial measures use in the performance management systems in the past. Therefore, researchers have been trying to arrive at efficient and effective approaches to measure performance. In fact of Vietnam, a lot of companies or banks manage their business operations by using some normal financial indicators. This is appropriate in the past, but today in the business world the enterprises are required to manage the firm based on a set of well-set indicators. Despite of their importance, financial indicators can only show us what was happened in the past and fail to provide what will occur in the future.

The aim of this study is to apply BSC tool and Exploratory Factor Analysis (EFA), Confirmatory Factor Analysis (CFA), and Structural Equation Modelling (SEM) to analyse, measure, and evaluate firm performance of Vietnamese banks. In order to achieve this aim,

the following objectives of the current study are advanced. To overview analysis the actual of the implementation BSC in the Vietnamese banks.

- To determine which factors of BSC actually would affect firm performance of Vietnamese banks.
- To test and generate model which is the best fit model used for the application and implementation BSC in Vietnamese banks.
- To propose potential solutions on enhancing efficiency of the implementation BSC in Vietnamese banks.

LITERATURE REVIEW

The balanced scorecard approach

The BSC approach offered by previous studies addresses the issues of divergent stakeholder goals and gauging managers' effectiveness. Kaplan and Norton (1992) propose four balanced perspectives: financial, customer, internal business processes, and learning and growth perspective. The BSC approach emphasizes that, in order to achieve objectives in the financial perspective, all objectives and measures in other perspectives should be linked (Gosselin, 2005). To achieve a synergetic effect, firms should emphasize the cause and effect relationship among the BSC measures. Olve, Roy and Wetter (2000) argued that improved value in human resource and development capital should be the leading indicators of improvement in customer capital and profitability. In this study, the non-finance measures are formed from the real situation of the banking operations in Vietnam combined the advances in the world. Therefore, this thesis would like to go further by integrating the opinions of previous studies to evaluate more specifically the interrelationships among the four perspectives of BSC through confirming factor analysis CFA combined with testing structural model SEM.

Balanced scorecard and bank performance

The relationship between BSC and organizational performance can be referred through several other similar studies. Hoque and Jame (2000) have found that there is relationship between BSC and performance. They discovered that there is positive relationship in the use of non-financial measures, particularly, internal business process and innovation and learning measures, and organizational performance. Based on the above literature review, this study develops and a framework to analyze the factors in the BSC how impacting to the performance of banks in Vietnam. More specifically, this study is analyzed based on the method of EFA, CFA. In addition, the data analysis deeper and verification based on the analysis of SEM in this study. The next section the new point and the effectiveness of this research will be clarify through the specifically introduction about the application of the above method.

METHODOLOGY

Research Hypotheses

According to Davis and Albright (2004) confirmed the relationship between the internal performance measures and the implementation of BSC in banking industry. Moreover, this research points out that there is a relationship between growth perspective, learning, and financial. Though the research objectives are mentioned above and the improvement from the previous study, the research hypotheses are proposed as follows:

H1: The BSC has a positive impact on firm value (Tq).
H2: The BSC has a positive impact on earning per share (EPS).
H3: The BSC has a positive impact on stock rerturn (Ri).

One of the first researchers (Kaplan and Norton, 1992, 1996) the BSC would pave the way of balanced scorecard, and the comprehensive growth for the firms. As the result, it is argued that the BSC as well as its four dimensions have a positive impact on firm performance. To test the argument, four hypotheses are proposed, one of which argues that the composite BSC indicator has a positive impact on firm performance. The hypothesis four are proposed as follows:

H4: The BSC has a positive impact on firm performance of Vietnamese banks.

Measures

Based on the situation of world economic in general and the banking industry in Vietnam in particular, the research objectives of this topic are posed, these objectives which are taken out from the previous study, the measures are developed. In this study, we can see that there are 7 measures are used. First, the Bank's performance includes three measures: firm value, earning per share, stock return. Secondly, the BSC includes four measures are grouped into two aspects: non-financial and financial. All measures are measured by the 5-level Likert measure, where 1: strongly disagree and 5: strongly agree.

Balanced Scorecard
Non - Financial

The customer dimension defines how a particular organization can discriminate itself from the competitors to attract, retain, and strengthen the relationships with the targeted customers. It is utmost valuable and crucial as it helps an organization connects its internal processes to improve and thrive for better outcomes with its customers, as suggested by Kaplan and Norton (2001). Furthermore, Kaplan and Norton (1996) also propose five variables: market share, new customer rate, customer retention rate, customer satisfaction, and customer margin. Because the data of these variables are mostly not available, the questionnaires are delivered to collect the information. From here, the measure of the customer dimension is formed. The survey questions are in table A.1 (appendix).

The internal business process dimension: Kaplan and Norton (2001) point put that the internal operating process would consist of the three procedures: innovation, operation and after safe service. The innovation capability refers to a firm's ability to develop new service and products. BSC is not only paying attention to a simple process to improve the existing operators, but also focus on the request of customers and shareholders as a starting point in order to satisfy customers and shareholders. To achieve effective performance in the target market, the bank must provide values can satisfy the customer demand, and improve internal strategy. From these conclusions and ideas, the questions are designed as shown at table A.2 (appendix).

The learning and growth dimension: It confirms an investment, which the organization must carry out to achieve long-term performance in the future, includes the ability of employees, organization information system and so on. Kaplan and Norton acknowledge that the learning and growth measures are the most difficult to select; therefore, they suggest the following measures as examples: employee empowerment, employee motivation, employee capabilities, and information systems capabilities. Since the proposal of researchers has succeeded before, the measure is built from the questions as shown at table A.3 (appendix).

Financial

Variable Definition: Financial measures are typically focused on profitability-related measures (the basis on which shareholders, in turn, typically gauge the success of their investments), such as return on capital, return on equity, return on sales, etc. (Kaplan and Norton, 1992; Lipe and Salterio, 2000). In this study, to ensure covering of the entire financial situation operation and to ensure the limit of the study is within the framework of the financial sector, nine financial indicators are proposed. Debt ratio for capital structure, liquidity ratio for describing a bank's liquidity, equity over assets ratio, operation leverage and financial leverage for degree of leverage, total asset turn over for efficiency of asset utilization, net profit margin for profitability, return on total assets and return on equity ratio for return ratio.

Calculation and Standardization of Measure: Based on the annual reports of the banks and the stock price at the study time of stock market, the assessment indicators are calculated. Formulae are used to calculate nine above indexes as shown at table A.4 (appendix). After calculating fully and exactly nine financial indicators, the results are standardized.

The formulae to standardize measure are used following:

$$Z = \frac{(X_i - \bar{X}) \times \sqrt{(n-1)}}{\sigma}$$

(1)

Where,

σ : sample standard deviation.

X_i (i=1 →n, n=31): sample size.

$\bar{X}$: mean sample size.

Design the 5-level Likert measure: The standardized data are transferred into a 5 level Likert measure by using IF clause in Excel. The syntax for the IF function is:

IF (condition, [value_if_true], [value_if_false])   (2)

Where,

Condition is the value that you want to test.

Value_if_true is optional. It is the value that is returned if condition evaluates to true.

Value_if_false is optional. It is the value that is return if condition evaluates to false.

In this study, IF syntax is as follows:

IF(StandardizedResult$_n$>0.8,5,
IF(StandardizedResult$_n$>0.6,4,   (3)
IF(StandardizedResult$_n$>0.4,3,
IF(StandardizedResult$_n$ >0.2,2,1))))

With n: 1=>9.

This clause is understood and explained as follows: based on the standardized results of financial indicators in the finance element of the BSC and the indicators of the PER, the value landmarks which corresponded to the 5-level Likert measure are convened as follows:

Level 5: StandardizedResult > 0.8.
Level 4: StandardizedResult > 0.6.
Level 3: StandardizedResult > 0.4.   (4)
Level 2: StandardizedResult > 0.2.
Level 1: StandardizedResult ≤ 0.2.

Bank's Performance

Literature has suggested that the measurement of the firm performance could be obtained from three aspects: firm value, corporate profitability, and stock return. According to MCConnell and Servaes (1990); Morck, Shleifer, and Vishny (1988) argue that firm value could be estimated by Tobin's q ratio. For corporate profitability and stock return, the

common measures are earning per share (EPS) and the sum of capital gain yield and dividend yield, respectively. From these conclusions, the measure of bank's performance is developed and included the indicators as follows at table A.5 (appendix). After the calculation is finished, the results of three indicators are also standardized and converted into a 5 level Likert measure.

Research method
Data Collection

The first tool is questionnaire: for non-financial aspect, two questionnaires are designed: a first questionnaire for the customer object, a second questionnaire for the manager object. The second tool is the annual statement of the banks: for the financial dimension of BSC and bank's performance, the data in the annual reports of 31 banks (to be supplied on request).

Sample Size

The data analysis methods used for this study was based on analysis of linear structural model SEM, to achieve the reliable estimation for this method, samples are usually large size with n> 200 (Hoelter, 1983). Based on rule of experience is a minimum 5 samples for a parameter, this needs to estimate. In this study, the theoretical model for non-finance aspect has 45 questions to be estimate; finance aspect has 9 estimated parameters.

Analysis method
Exploratory Factor Analysis – EFA

After forming and assessing measures, using EFA is conducted such as the first important step to determine the correlation between the measures or the variables in the data of this study. EFA has been defined as follows: could be described as orderly simplification of interrelated measures. EFA, traditionally, has been used to explore the possible underlying factor structure of a set of observed variables without imposing a preconceived structure on the outcome (Child, 1990). By performing EFA, the underlying factor structure is identified.

Confirmatory Factor Analysis and Structural Equal Model

Structural equal model of AMOS 17.0 is appropriate to use when the research is available some knowledge about the structure of basis latent variable. CFA is the next step of EFA to test whether the preexisting theoretical models as the basis for a set of observations and CFA is also a form of structural equation modeling (SEM). CFA method in SEM analysis is more advanced than the traditional methods such as the correlation coefficient method, and EFA.

In hypothesis testing and research models, SEM also has many characteristics better than the traditional multivariate analysis methods such as multiple regressions, and the multivariate regression because it can calculate the measurement errors. Furthermore, in practice, the errors always appear in the measurement.

Measuring fit level of the model

Test Chi-Square (χ^2): χ^2 indicates the overview appropriate level of the entire model at significance level P-Value = 0.05. Actually, this is very difficult to happen because χ^2 is sensitive with a large sample size and a strength test. Therefore, we only use actually χ^2 / df to evaluate.

Ratio Chi-Square / degrees of freedom (χ^2 / df) : χ^2 / df are used to measure an appropriate level in detail than the model. According some researchers suggest that $1 < \chi^2/df < 3$, another researchers suggest that the χ^2 as small as possible and that $\chi^2/df < 3:1$. Furthermore, in an actually study two cases are distinguished: first, $\chi^2/df < 2$ (sample size N > 200); second, $\chi^2/df < 3$ (when the sample size N < 200). Their mean is that the considered model is fit well (Kettinger and Lee, 1995).

Other relevant indicators:

GFI, AGFI, CFI, NFI… indicators have value > 0.9 is considered a fit model well. If the value is 1, we can say the model is perf (Segar and Grover, 1993; Chin and Todd, 1995).

GFI: measures absolutely the appropriate level of the structural model and the measurement model with the survey data.

AGFI: adjusted GFI values as degrees of freedom in the model.

RMR: RMR value is greater, its mean that residual variance is higher. It reflects the model which has a bad appropriate.

RMSEA: is an important indicator, it determines the appropriate level of the model compared to the overall.

NFI: measure the difference of the normal distribution of χ^2 between the model independent (single factor, have the coefficients is 0) and thevariance measurements, and multi-factor models. The value proposed NFI> 0.9 (Hair, Anderson, Tatham, and Black, 1998; Chin and Todd, 1995).

$$NFI = (\chi^2 \text{ null} - \chi^2 \text{ proposed}) / \chi^2 \text{ null} = (\chi^2 \text{ Mo} - \chi^2 \text{ Mn}) / \chi^2 \text{ Mo} \qquad (5)$$

Where,

Mo: Original model

Mn: The model fit.

The probability: has value > 0.05 are considered a good fit model (Arbuckle and Woth, 1999; Rupp and Segal, 1989). This means that we cannot reject the null hypothesis H_0 (the hypothesis of good model), that is not looking a model better than the current model. In studies, in the fields of social sciences, all the causal relationships propose a reliability at 95% (p = 0.05) (Cohen, 1988).

Convergent validity: Gerbring & Anderson (1988) argues that measures achieve the convergence value when the standard weight of measure are high (> 0.5) and statistically significant (P <0.05).

One-dimensionality

According to Steenkamp & Van Trijp (1991), the fit level of the model with market data gives our necessary and sufficient condition to set off the observed variables which achieves the one-directional.

Discriminant validity

In saturated model, we can test the discriminant validity of the concept which is freely related to each other with the concept of the studied. In the overall range, we can also test the correlation coefficient (r) between the concept which has really different from 1 or not. Actually, if it is different, it will achieve worth distinguishing.

Testing principles:

$H_0: r = \rho_0$

$H_1: r \neq \rho_0$

Using the formula:

$$T = \frac{|r - \rho_0|}{\sqrt{\dfrac{1 - r^2}{n - 2}}}$$

(6)

After calculating: check distribution table Student t-Distribution Probability Table $t, \dfrac{\alpha}{2}, n-2$. If T is larger than $t, \dfrac{\alpha}{2}, n-2$, hypothesis Ho is rejected.

In this study, Excel is used to calculate with formulas functions as follows.

Standard error (SE):

$$SE = SQRT((1-r^2)/(n-2))$$

(7)

Regression coefficient (RC):

$$RC = (1-r)/SE$$

(8)

*P-value: TDIST returns the Per*centage Points (probability) for the Student t-distribution where a numeric value (x) is a calculated value of t for which the Percentage Points are to be computed. The t-distribution is used in the hypothesis testing of small sample data sets. Use this function in place of a table of critical values for the t-distribution.

$$TDIST(RC, degrees\_freedom, tails) \tag{9}$$

Where,

RC: is the numeric value at which to evaluate the distribution.

Degrees_freedom: is an integer indicating the number of degrees of freedom.

Tails: specifies the number of distribution tails to return.

TINV: Returns the t-value of the Student's t-distribution as a function of the probability and the degrees of freedom.

$$TINV\ (probability, degrees\_freedom) \tag{10}$$

Where,

Probability: is the probability associated with the two-tailed Student's t-distribution.

Degrees_freedom: is the number of degrees of freedom with which to characterize the distribution.

Testing composite reliability composite reliability and variance extracted

Composite reliability (ρ_c), Variance extracted (ρ_{vc}): is calculated by the following formula:

$$p_c = \frac{(\sum_{i=1}^{p} \lambda_i)^2}{(\sum_{i=1}^{p} \lambda_i)^2 + \sum_{i=1}^{p}(1-\lambda_i^2)} \quad \text{(Joreskog 1971)} \tag{11}$$

$$p_{vc} = \frac{\sum_{i=1}^{p} \lambda_i^2}{\sum_{i=1}^{p} \lambda_i^2 + \sum_{i=1}^{p}(1-\lambda_i^2)} \quad \text{(Fornell \& Larcker 1981)} \tag{12}$$

Where,

λ_i: Standardized weights of observed variable i.

$1-\lambda_i^2$: The variance of measurement errors observed variables i.

p: is the number of observed variables measure.

With ρ_c, $\rho_{vc} \geq 0.5$.

Cronbach's Alpha: the item total correlation variable coefficients < 0.3 will be disqualified. measure is acceptable when the Cronbach's Alpha ≥ 0.6. However, it should be noted that if the Cronbach's Alpha is too high (> 0.95), it be able appears admit observed variables (Redundant items) in the measurement measures.

RESULT

Statistic analysis

The questionnaires were personally delivered and collected from May 27, 2012 to February 8, 2013 to customers and managements in thirty one Vietnamese banks. There were totally 342 questionnaires to be delivered; however, these are only 335 questionnaires to be collected. All the data is collected through the 5-level Likert scale with questionnaires are described above. Before going further into deep data analysis which is the foremost focus of this study, it is necessary to discuss the structure of the survey objects as the basic information about this survey.

Table 1 : Descriptive Statistics Demensions

	Mean	Min	Max	Std. Deviation
Customer (CUS)	3.50	2	4.93	0.68
Internal Business Process (INT)	3.46	2	4.78	0.68
Learning and Growth (LEA)	3.46	2	4.29	0.72
Financial (FIN)	3.05	1	5.00	1.46
Firm performance of Vietnamese banks (PER)	3.90	1	5.00	1.14

As showed in this table, to explore about the BSC and PER, we have to learn about the dimension of them. This data shows that the dimensions of BSC and PER have a difference, because their mean value from 3.05 to 3.90. In BSC, the mean, min, max, and standard deviation of customer dimension is 3.50, 2, 4.93, and 0.68, and achieves the highest level of concentration. And the finance dimension achieves the lowest concentration, with mean, min, max, and standard deviation is 3.05, 1, 5, and 1.14. It mean that when BSC is done in Vietnam, the aspects of customer dimension achieve a fairly efficiency. The finance dimension is not.

Exploratory Factor Analysis

After these measures are overall assessed by the descriptive statistical method, the variable number of them is reduced by EFA method of SPSS.17 software. This reduction makes the variables increase their significance level. These measures include BSC (the independent variable) and firm's performance of Vietnamese banks (the dependent variable).

Customer dimension: After dropping out ten variables, in the scree plot, a red line through the smaller eigenvalues makes the debris or break occurs. 4 factors above this debris or break are retained. To fit with their meaning, these four factors are named. The result of these four factors KMO is 0.685 (>0.5), Sig<0.05. It said that data of the customer dimension is appropriate. 481.689% of the data's variability is explained by four factors. And the eigenvalue of them with the principal components extraction method and the varimax rotation are all greater than 1. This suggests that the measure items are one-dimensional.
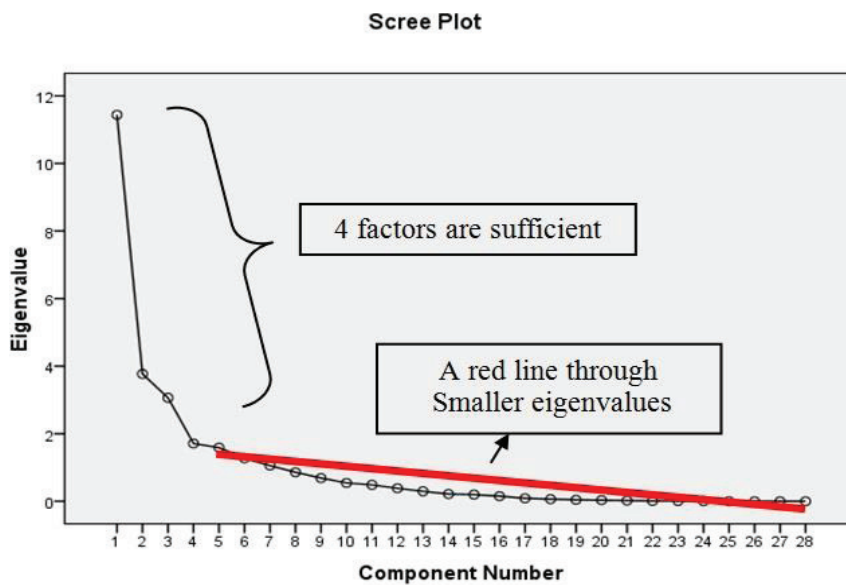
Figure 1: Scree Test Criterion of Customer Dimension (SPSS Output)

Internal Business Process dimension: In the scree plot, 2 factors above this debris or break are retained. For the same way, to fit with their meaning, these 2 factors are named. The result of these 2 factors KMO is 0.613 (>0.5), Sig<0.05. It said that data of internal business process dimension is appropriate. 79.747% of the data's variability is explained by 2 factors. And the eigenvalue of them with the principal components extraction method and the varimax rotation are all greater than 1. This suggests that the measure items are one-dimensional.
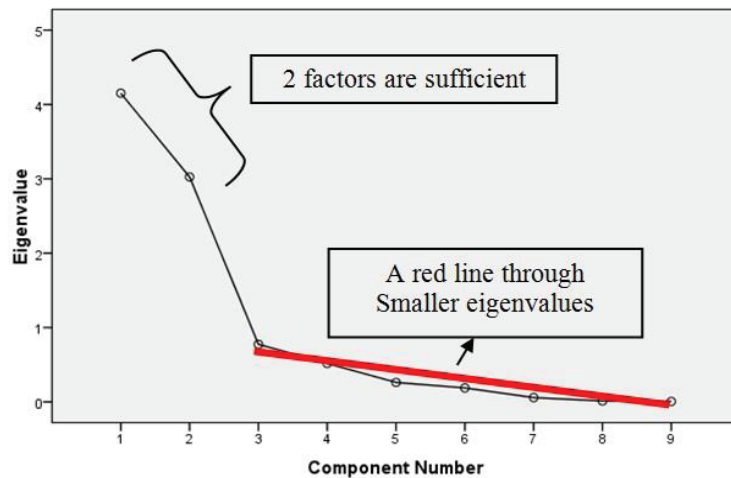
Figure 2: Scree Test Criterion of Internal Business Process Dimension (SPSS Output)

Learning and growth dimension: After dropping out variables – C.6, in the scree plot. The learning and growth dimension of BSC has only one factor. To fit with their meaning, this factor is named. The result of this factor: KMO is 0.921 (>0.5), Sig<0.05. It said that data of this dimension achieve a high appropriation. 87.027% of the data's variability is explained by 1 factor. And the eigenvalue of them with the principal components extraction method and the varimax rotation are all greater than 1. This suggests that the measure items are one-dimensional.
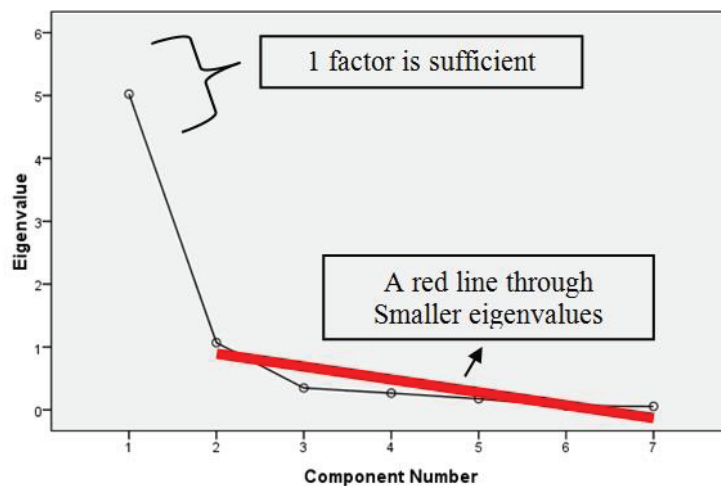
Figure 3: Scree Test Criterion of Learning and Growth Dimension (SPSS Output)

Finance dimension: After dropping out 2 variables, In the scree plot, 2 factors above this debris or break are retained. For the same way, to fit with their meaning, these 2 factors are named. The result of these 2 factors KMO is 0.683 (>0.5), Sig<0.05. it said that data of finance dimension is appropriate. 69.022% of the data's variability is explained by 2 factors.

And the eigenvalue of them with the principal components extraction method and the varimax rotation are all greater than 1. This suggests that the measure items are one-dimensional.
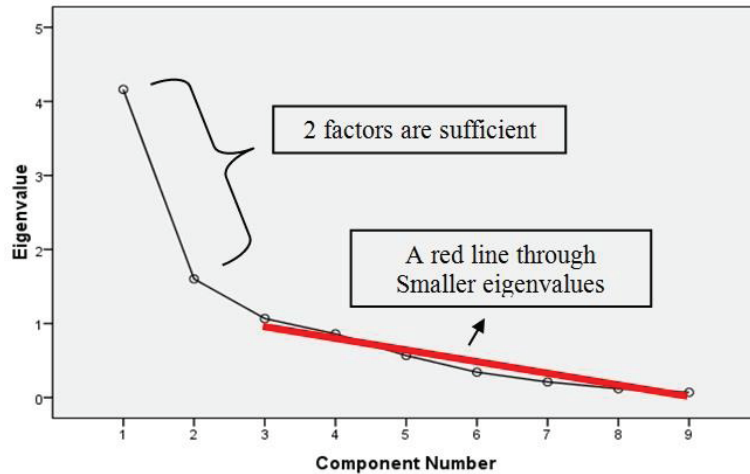
Figure 4: Scree Test Criterion of Financial Dimension (SPSS Output)

Bank's performance dimension: A red line through the smaller eigenvalues makes the debris or break occurs. The point above this debris or break indicates the number of factors to be retained.
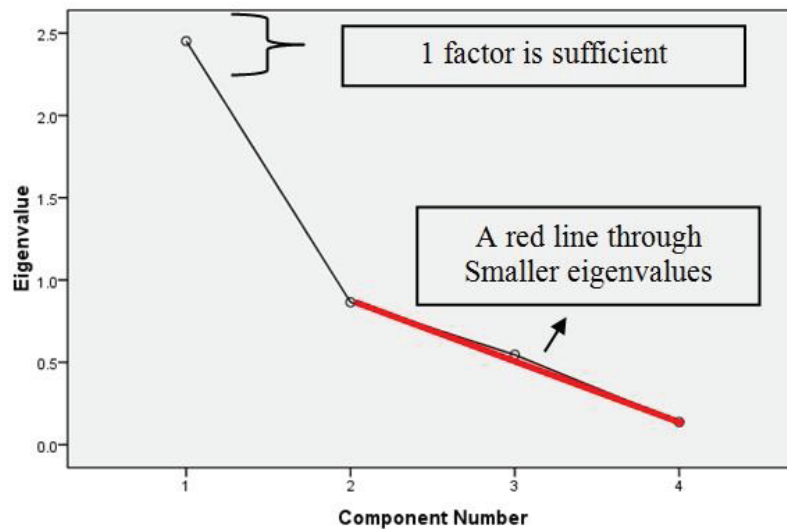
Figure 5: Scree Test Criterion of Bank's Performance of Vietnamese Banks (SPSS Output)

Confirmatory factor analysis

The second CFA result of the BSC measure and bank's performance measure show indicators significant P value of the measure are good (< 0.05), as shown in table A.6

(appendix). In addition, the standardized weights are high (> 0.5). Therefore, we can conclude that the observed variables use to measure the bank's performance measure and 4 dimension of the BSC measure achieve the convergence value as well as the model achieves the convergence value. Measurement model with the degrees of freedom is presented. It shows that the model achieves compatible the level of with market data with the following indicators: Chi-square χ^2 = 342.296 (>0.05), with p-value = 0.000 (<0.05); Chi-square/df = 2.2519 ($\leq$ 3); GFI = 0.926 ($\geq$ 0.9), AGFI = 0.939 ($\geq$ 0.9), CFI = 0.963 ($\geq$ 0.9), TLI = 0.945 ($\geq$ 0.9); RMSEA = 0.042 ($\leq$ 0.05) as shown in figure B.2 (appendix). Other arguments, based on the results we can commented that of model results are consistent with of survey data elements 4 elements of BSC and the Bank's performance. It proves that the data used in this survey are statistically significant.

Test hypotheses by Structural equation modeling

SEM 1: Measurement model which is presented has 167 degrees of freedom. The final SEM1, result shows that the model achieves the compatible level with market data following: Chi-square χ^2 = 527.735 (>0.05), with p-value = 0.000; Chi-square/df = 2.3284 ($\leq$ 3); GFI = 1.257 ($\geq$ 0.9), AGFI = 1.937 ($\geq$ 0.9), CFI 0.995 ($\geq$ 0.9), TLI = 0.983 ($\geq$ 0.9); RMSEA = 0.038 ($\leq$ = 0.05) as show in figure B.2 (Appendix). The standard error (SE) of the variables has correlation together. Specifically, most of SE indicates are larger than 0.3 as show in table A.7 (appendix). SEM 1, the standardized coefficients have both of the positive sign (+) and negative sign (-) which consider that these variables have the directly proportional impact and the inversely proportional impact to E.1, E.2, and E.3. In addition, for each dimension of PER, only a few factors of BSC impacts it and this impact are not of the 4 dimension of BSC as show in table A.10 (appendix). Thus, the results clearly confirmed that have an uneven and incomplete impact of four dimensions of BSC to PER. Conclusion, the H1, H2, H3 are not accepted. Therefore, the process research is continued by testing hypothesis H4 and set up model SEM 2 to find out the impact of BSC to PER.

SEM 2: the standardized coefficients have positive sign (+) which considers that these variables have the directly proportional impact to E.1, E.2, and E.3 as shown in table A.9 (appendix). Specifically, the impact of order 4 factors to PER has been reviewed as follows: the first is the two factors of the customer dimension CUS.1 and CUS.2 impact PER the strongest (βCUS.1 = 0.861, βCUS .2 = 0.819). The second is two factors FIN.2 and FIN.1 of The financial dimension (βFIN.2 = 0 .835, βFIN.1 = 0.755). The third is factor LEA in the learning and growth dimension (βLEA = 0.147). The final is the factors INT.2 of the internal business process dimension with (βINT.2 = 0.118).This result confirms again the conclusions of this study. The model SEM2 was chosen as the final model for this study which achieves the study objectives of this study
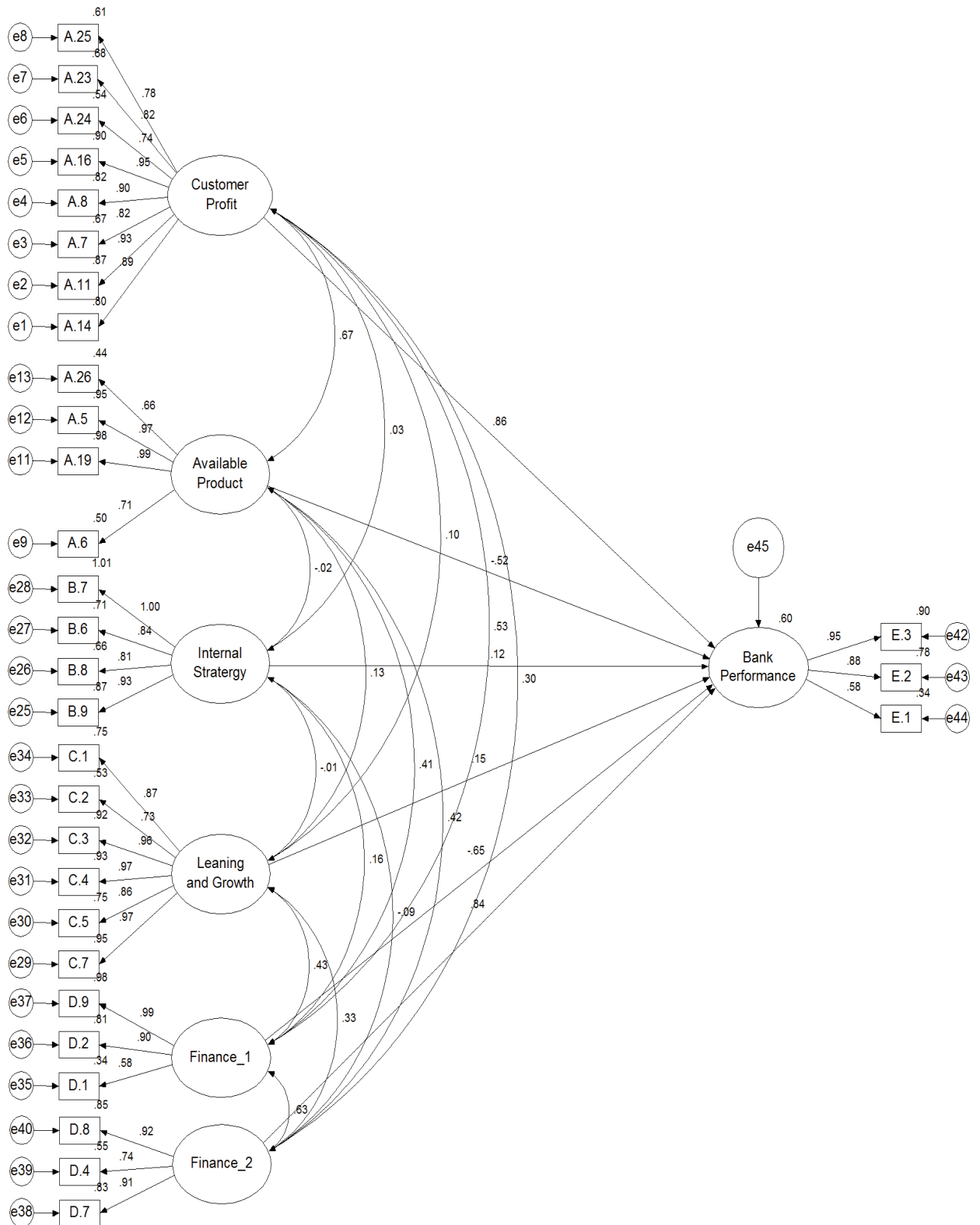
Figure 6: Structural SEM 2

CONCLUSIONS

Research implication and contribution

CFA show that there are significant relationships between four dimensions of BSC with firm performance of Vietnamese banks. The model SEM 2 is an important contributor to firm performance of Vietnamese banks. It appears to be the first study to combine the BSC with SEM to find out the best fit model for Vietnamese banks. Beside, this study research about how Vietnamese banks use the BSC as a tool which is applied to commercial banks performance operation and management system. It is extremely important to maintain competitive advantages as business activities of the banks are always facing a changing market and serious competition. To maintain and develop in the market place, banks should put their efforts in implementation BSC effectively. SEM has provided the best result of significant impact of BSC's factors to PER.

In general, in this study the measurable results show that measures are built and tested on the international market can be used for studying in Vietnam through adjustments and additions in accordance with the actual conditions. In the practical aspect, four dimension of BSC as customer, internal business process, learning and growth, and finance have an important role to performance of the Vietnam banks. Therefore, these measures help the managers to measure bank performance in the banking BSC Vietnam.

Solution

The result of customer satisfaction (CUS.3) and the rate of customer (CUS.4) showed that these two factors do not have an impact on PER. This proves that the disbursement time of loan, mutual fund has a large number of beneficiaries, working environment, procedures to apply for a loan, service style of the credit staff, and the ability to maintain the traditional customers is not effective in the implementation process BSC in banking Vietnam. Therefore, Vietnam has been eliminated from the investment list of many foreign investors in recent years. Because market share deteriorate with Vietnam index fell over 62% in September 2007, from 1106.6 points down to 416.65 points on 4/6.

The solution to promote activities to raise funds for mutual funds: encourage social insurance funds and insurance companies to invest in the stock market through investment and become a shareholder or founder of the investment fund. In addition, encourage the use of revenues from life insurance to invest in the stock market through investment and become a shareholder or founder of the investment fund; and increasing popularity and knowledge of securities to the public stock market investors.

These solutions increase investment activities of the mutual fund: increase the size of the stock market in Vietnam, accelerate the equitization process of state owned enterprises and associated privatization process with the listing of shares on the stock market, expand and upgrade activities of the of securities transactions centers; and recommend business

implement management model. This model requires businesses must be proactive and open information about the companies or banks as well as to establish investors relation. Focus on training of the fund managers have high professional qualifications: to create confidence for people to invest, the fund managers.

For banks, the introduction of electronic banking services Homebanking to help banks improve service quality and operation efficiency. Bank will reduce fixed costs, savings cost to open branches and transaction offices and reduce staff numbers. In addition, electronic banking services Homebanking help the banks improve the efficiency of capital use. Banks should focus on this issue because the main building is the security technology. Safety will create trust in customers, giving customers the comfort, peace of mind when trading with banks. At the same time, banks need to enlist the support of technical strategic partnerships to learn experience as well as inviting foreign consulting experts in investment and using security technologies, technology secure payment.

REFERENCE

1. Arbuckle, J., & Wothke, W. (1999). "AMOS 4.0 Users' Guide*". Chicago: Small Waters*.
2. Child, D. (1990). "The Essentials of Factor Analysis (2rd ed.)". London: Cassel Educational Limited.
3. Chin, W., & Todd, P. (1995). "On the Use, Usefulness, and Ease of Use of Structural Equation Modeling in MIS Research: A Note of Caution". *MIS Quarterly, 19*(2), 237-246.
4. Cohen, J. (1988). "Statistical Power Analysis for the Behavioral Sciences (2rd ed.)". *Hillsdale, New Jersey: Lawrence Erlbaum Associates.*
5. Davis, S., & Albright, T. (2004). "An Investigation of the Effect of Balanced Scorecard Implementation on Financeial Performance". *Management Accounting Research, 15*(2), 135-153.
6. Gosselin, M. (2005). "An Empirical Study of Performance Measurement in Manufacturing Firms". *International Journal of Productivity and Performance Management, 54*(5/6), 419-437.
7. Govindarajan, V. (1988). "A Contingency Approach to Strategy Implementation at the Business Unit Level: Integrating Administrative Mechanisms With Strategy". *Academy of Management Journal, 31*(4), 828-853.
8. Hair, J. F., Anderson, R. E., Tatham, R. L., & Black, W. C. (1998). "Mutivariate Data Analysis (5th ed.)". *Upper Saddle River, New Jersey: Prentice Hall.*
9. Hoelter, J. W. (1983). "Factorial Invariance and Self-Esteem: Reassessing Race and Sex Differences". *Social Forces, 61*(3), 853-846.
10. Hoque, Z., & James, W. (2000). "Linking Balaced Scorecard Measures to Size and Market Factors: Impact on Organizational Performance". *Journal of Management Accounting Research, 12*, 1-17.

11. Kaplan, R. S., & Norton, D. P. (1992). "The Balanced Scorecard-Measures that Drive Performance". *Harvard Business Review, 70*(1), 71-79.
12. Kaplan, R. S., & Norton, D. P. (1996). "Translating Strategy into Actions: The Balanced Scorecard". *Boston, MA: Harvard Business School Press.*
13. Kaplan, R. S., & Norton, D. P. (Mar. 2001). "Transforming the Balanced Scorecard from Performance Measurement to Strategic Management: Part I". *Accounting Horizons, 15*(1), 87-104.
14. Kettinger, W. J., & Lee, C. C. (1995). "Perceived Service Quality and User Stisfaction with the Information Services Function". *Decision Sciences, 25*(5-6), 737-766.
15. McConnell, J., & Servaes, H. (1990). "Additional Evidence on Equity Ownership and Corporate Value". *Journal of Financial Economics, 27*, 595-612.
16. Morck, R., Shleifer, A., & Vishny, R. W. (1988). "Management ownership and market valuation". *Journal of Financial Economics, 20*, 293-315.
17. Olve, N.-G., Roy, J., & Wetter, M. (2000). Performance Drivers: A Practical Guide to Using the Balanced Scorecard. *Chichester: John Wiley & Sons, Ltd.*
18. Rupp, M. T., & Segal, R. (1989). "Confirmatory Factor Analysis of a Professionalism Scale in Pharmacy". *Journal of Social and Administrative Pharmacy, 6*, 31-38.
19. Segar, A. H., & Grover, V. (1993). "Rexamining perceived ease of use and usefulness: A confirmatory factor analysis". *MIS Quarterly, 17*(4), 517-525.
20. Steenkamp, J.-B. E. M., & Trijp, H. C. M. v. (1991). "The use of LISREL in Validating Marketing Constructs". *International Journal of Marketing 8*, 283-299.

Appendix

Table A.1: The Variables of the Customer Dimension Measure

Code	Items
A.1	Working environment is very convenient.
A.2	Service attitude of the credit staff is very caring.
A.3	Service style of the credit staff is very professional.
A.4	Consulting customer use of loans effectively.
A.5	Various types of loan are available.
A.6	Characteristics of loan products are fascinating.
A.7	Lending rates are very reasonable.
A.8	Service fees are very reasonable.
A.9	Procedures to apply for a loan are very simple.
A.10	The value of the collateral is reasonably evaluated.
A.11	Appraisal of the financial capacity of the client is carefully evaluated.
A.12	Appraisal of the feasibility of the business production plan is practically evaluated.
A.13	Appraisal actual of collateral is practically evaluated.
A.14	Ability to provide borrowed capital to customers is very well.
A.15	After credit profile has completed, the disbursement time of loan is very quick.
A.16	The flexibility to extend the principal loan is high.
A.17	The ability to maintain the traditional customers is high.
A.18	Does your bank offer any mutual fund?
A.19	What kind of the mutual fund?
A.20	The bank has a good ability to introduce the mutual fund to investors.
A.21	Investors can buy the mutual fund easily.
A.22	The mutual fund has a large number of beneficiaries.
A.23	Mutual fund has the good investment ability.
A.24	Mutual fund has the high profitability.
A.25	Saving interest rate of the customer is high.
A.26	There are many different foreign currencies for trading.
A.27	The procedure of exchanging foreign currencies is convenient.
A.28	Card services are convenient.
A.29	Mortgage services are good.

Table A.2: The Variables of the Internal Business Process Dimension Measure

Code	Items
B.1	Monitoring the customer satisfaction
B.2	Identifying the strengths and weaknesses of the bank
B.3	Continuously improving the credit process
B.4	Closely monitoring the stages in the credit process
B.5	Researching and updating the new technology to support the credit work.
B.6	Updating information about competitors to set up a better competitive strategy
B.7	Having various promotions and awards to attract customers
B.8	Having proper strategy to improve the quality of products
B.9	Having proper strategy to diversify products closer to customers

Table A.3: The Variables of the Learning and Growth Dimension Measure

Code	Items
C.1	Organizing the contests to choose staffs closely and strict.
C.2	Selecting the skillful and knowledgeable staffs.
C.3	Organizing the monthly skill training class to foster staffs.
C.4	Organizing the competitions among business units to build relationships in the system, encouraging the striving spiritual at work.
C.5	Monitoring the awareness, attitude of the staff to execute and serve customers.
C.6	Organizing the contests to review and reassess the working ability and management of staff in the bank.
C.7	Having good preferential regime to encourage, sustain and increase loyalty employees.

Table A.4: The Variables of the Financial Dimension Measure

Code	Items	Formula			
D.1	Debt Ratio	Debts	÷	Total Assets	(3.1)
D.2	Liquidity Ratio	Current Assets	÷	Current Liabilities	(3.2)
D.3	Equity Over Assets Ratio	Equity	÷	Total Assets	(3.3)
D.4	Operation Leverage	EBIT	÷	Sale	(3.4)
D.5	Financial leverage	net profit	÷	EBIT	(3.5)
D.6	Total asset turnover	Sales	÷	Total Assets	(3.6)
D.7	Net Profit Margin	net profit	÷	Sales	(3.7)
D.8	Return on total assets Ratio (ROA)	net profit	÷	Total Assets	(3.8)
D.9	Return on equity Ratio (ROE)	net profit	÷	Equity	(3.9)

Table A.5: The Variables of the Bank's Performance Dimension Measure

Code	Items	Formula	
E.1	Firm value (Tq)	$\dfrac{Debt - (Stockprice \times Number of share)}{Debt + Equity}$	(3.13)
E.2	Earnings per share (EPS)	$\dfrac{Net\,Profit\,AfterTax - Pr\,eference Divident}{Number of Common Share}$	(3.14)
E.3	Stock return (Ri)	$\dfrac{P_t - P_{t-1} + D_t}{P_{t-1}}$	(3.15)

where, P_t denoted close price at time t and D_t cash dividend at time t.

Table A.6: Standardized Regression Weight of Second CFA

			Estimate	S.E.	C.R.	P	Label
A.14	<---	CUS1	1.000				
A.11	<---	CUS1	1.053	.121	8.689	***	par 1
A.7	<---	CUS1	.734	.120	6.095	***	par 2
A.8	<---	CUS1	1.009	.131	7.712	***	par 3
A.16	<---	CUS1	1.001	.111	9.029	***	par 4
A.24	<---	CUS1	.685	.153	4.480	***	par 5
A.23	<---	CUS1	.782	.145	5.385	***	par 6
A.25	<---	CUS1	.818	.148	5.539	***	par 7
A.6	<---	CUS2	1.000				
A.19	<---	CUS2	1.436	.270	5.317	***	par 8
A.5	<---	CUS2	1.292	.241	5.354	***	par 9
A.26	<---	CUS2	1.041	.285	3.652	***	par 10
A.1	<---	CUS3	1.000				
A.22	<---	CUS3	1.151	.213	5.409	***	par 11
A.15	<---	CUS3	1.252	.223	5.619	***	par 12
A.17	<---	CUS4	1.000				
A.3	<---	CUS4	1.214	.224	5.411	***	par 13
A.9	<---	CUS4	1.489	.264	5.633	***	par 14
B.1	<---	INT1	1.000				
B.5	<---	INT1	1.071	.214	3.410	***	par 15
B.3	<---	INT1	1.018	.294	3.467	***	par 16
B.4	<---	INT1	1.180	.209	3.820	***	par 17
B.2	<---	INT1	1.142	.285	4.006	***	par 18
B.9	<---	INT2	1.000				
B.8	<---	INT2	.941	.141	6.659	***	par 19
B.6	<---	INT2	.858	.118	7.252	***	par 20
B.7	<---	INT2	.930	.071	13.016	***	par 21
C.7	<---	LEA	1.000				
C.5	<---	LEA	.917	.108	8.522	***	par 22
C.4	<---	LEA	1.019	.069	14.828	***	par 23
C.3	<---	LEA	.989	.070	14.197	***	par 24
C.2	<---	LEA	1.003	.180	5.587	***	par 25
C.1	<---	LEA	.921	.106	8.654	***	par 26
D.1	<---	FIN1	1.000				
D.2	<---	FIN1	2.211	.220	3.564	***	par 27
D.9	<---	FIN1	2.684	.209	3.786	***	par 28
D.7	<---	FIN2	1.000				
D.4	<---	FIN2	.840	.175	4.807	***	par 29
D.8	<---	FIN2	.952	.125	7.618	***	par 30
E.3	<---	PER	1.000				
E.2	<---	PER	.986	.151	6.518	***	par 67
E.1	<---	PER	.535	.150	3.575	***	par 68

Table A.7: Regression Weights of SEM 1 final time

			Estimate	S.E.	C.R.	P	Label
E.3	<---	CUS1	1.584	.413	3.837	***	par_67
E.3	<---	CUS2	-1.272	.508	-2.501	.012	par_68
E.3	<---	INT2	.513	.368	1.910	.056	par_69
E.3	<---	FIN1	-1.996	.770	-2.592	.010	par_71
E.3	<---	FIN2	1.030	.322	4.634	***	par_72
E.2	<---	FIN1	-2.549	.918	-2.777	.005	par_70
E.2	<---	CUS1	1.549	.436	3.556	***	par_73
E.2	<---	CUS2	-1.242	.529	-2.350	.019	par_74
E.2	<---	INT2	.631	.388	2.194	.028	par_75
E.2	<---	FIN2	1.178	.356	4.609	***	par_77
E.1	<---	FIN1	-1.251	.585	-2.136	.033	par_76
E.1	<---	FIN2	.447	.370	2.623	.009	par_78
E.1	<---	CUS1	.924	.300	3.079	.002	par_79

Table A.8: Standardized Regression Weights of SEM 1

			Estimate
E.3	<---	CUS1	.907
E.3	<---	CUS2	-.550
E.3	<---	INT2	.285
E.3	<---	FIN1	-.939
E.3	<---	FIN2	1.230
E.2	<---	INT2	.343
E.2	<---	FIN2	1.373
E.2	<---	FIN1	-1.172
E.2	<---	CUS1	.867
E.2	<---	CUS2	-.525
E.1	<---	FIN1	-.687
E.1	<---	FIN2	.623
E.1	<---	CUS1	.618

Table A.9: Standardized Regression Weights of SEM 2

			Estimate
PER	<---	CUS1	.861
PER	<---	CUS2	.819
PER	<---	LEA	.147
PER	<---	FIN1	.755
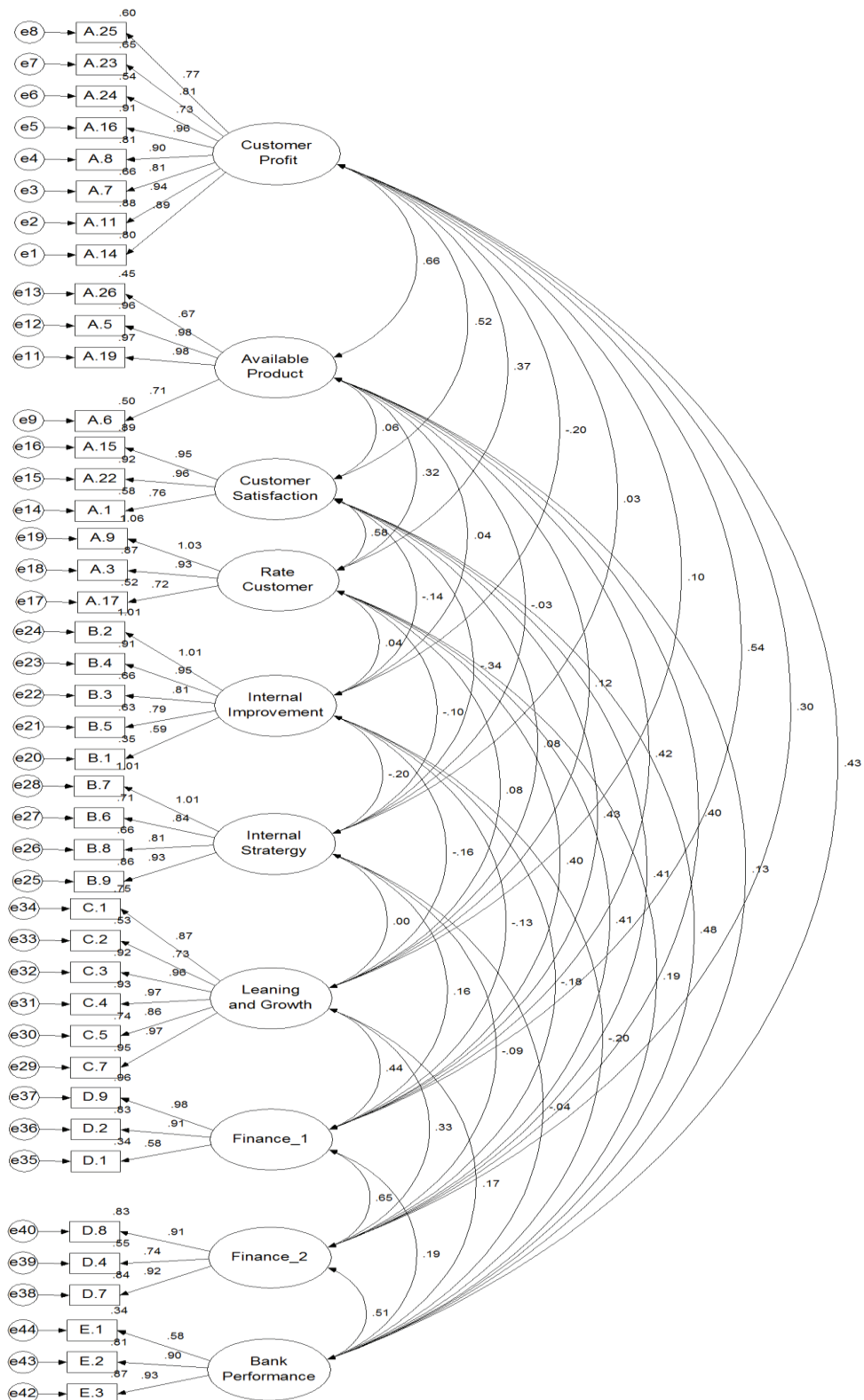
Figure B.1: The Second CFA Standardized Result
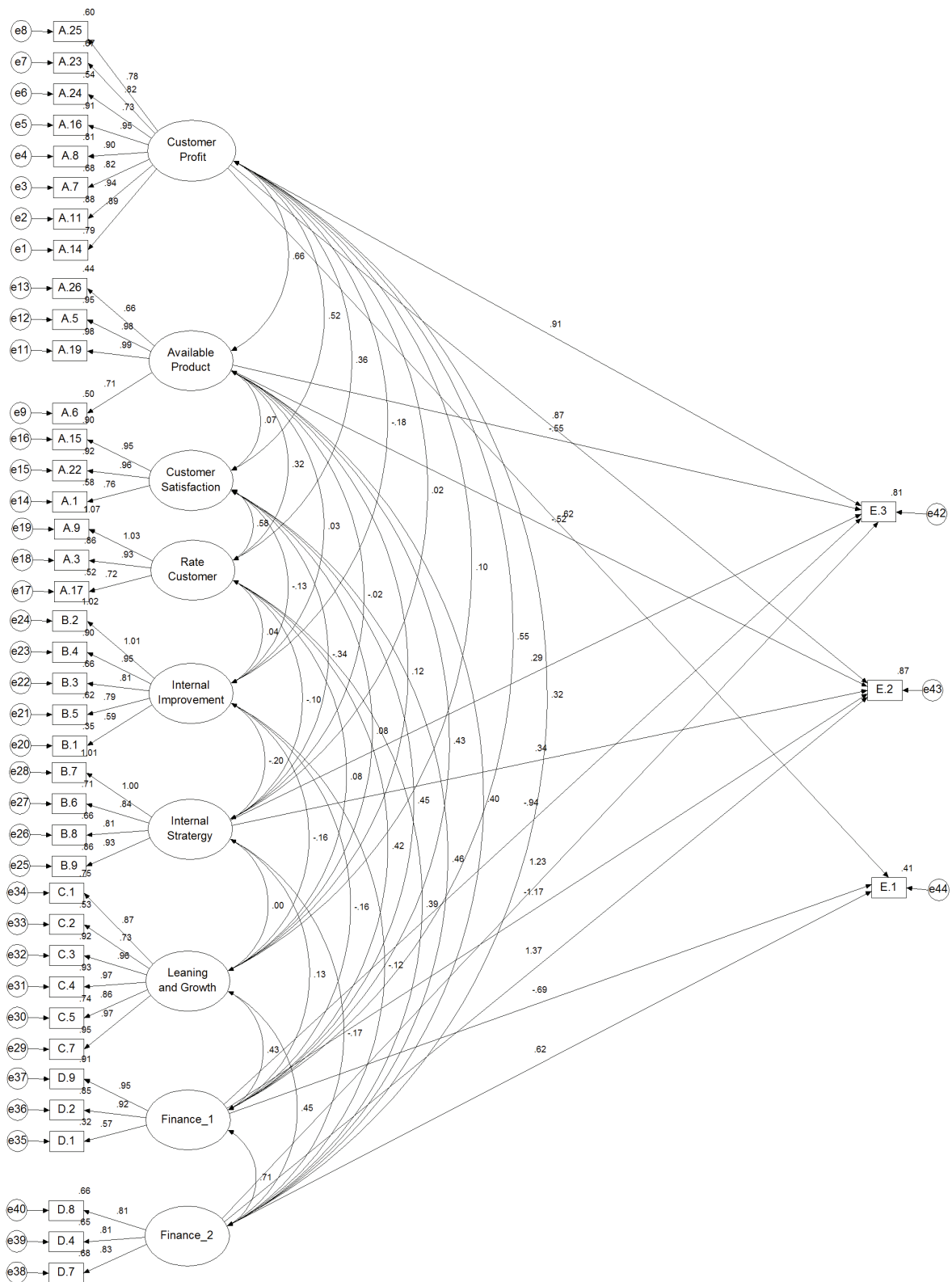
Figure B.2: The Result of Structural SEM 1

INVESTIGATING FACTORS IMPACTING SMART CITIES ADOPTION

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ABSTRACT

In order to find ways to development employment, quality of life, education, healthcare, energy, safety, mobility, in an ecological and sustainable way in our cities, cities can be transformed using modern information communication technologies (ICT) to connect citizens, government, and businesses and provide different services in a city. Smart cities are communities that use several information technologies (IT) to transform fundamental infrastructures and services in the city and the way these infrastructures and services work and communicate. All aspects of a city can be transformed by IT e.g., utilities, communication and transportation, public safety, education, healthcare, entertainment, and administration.

Motivated by the apparent lack of literatures in the area of an exploratory study on factors impacting smart cities adoption, this paper first developed a theoretical model for investigating factors impacting smart cities adoption, which includes factors such as perceived usefulness, perceived ease of use, entertainment, satisfaction, subject norm, smart city quality, security, privacy, legislation, technology, ubiquity, intention to use and cost. Second, a survey is developed to measure these constructs. Data was collected from 361 subjects using the stratified sampling method. Structural equation modeling method was used to analyze data. The findings show that legislation has positive correlations with security and privacy; perceived ease of use, perceived usefulness and entertainment have positive correlations with intention to use; and technology and ubiquity impact the intention to use via quality, entertainment and perceived ease of use and perceived usefulness. Finally, recommendations and guidelines are presented to assist smart city decision makings. Managerial and practical implications are also presented.

In this study, as subjects were recruited in one country, the future research will be to conduct a cross-cultural study on those constructs to considering impact factors inherited from cultural differences.

POWER MANAGEMENT BY ANALYZING INTERRUPTION OF POWER DISTRIBUTION SYSTEM IN PATTAYA

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ABSTRACT

This paper analyzed related factors caused power interruption in 22 KV Distribution System in Pattaya area using database of Provincial Electricity Authority (PEA). In order to manage the electrical power and improve the reliability of power distribution system, scenario analysis was applied as a main methodology. The effectiveness of each case was measured using reliability indices, SAIFI and SAIDI.

The results of the experiment indicate the improvement of reliability indices in studied area which imply better stability of power distribution system. In addition, the outcomes also provided several alternative options to prevent power interruption to reoccur and also suggest the productive way to improve the reliability of power distribution system.

Keywords : SAIFI, SAIDI, Scenario Analysis, Reliability, Power Distribution System, Power Interruption, Power management

INTRODUCTION

Pattaya was chosen to do the empirical study in this paper for several reasons. Apart from the fact that Pattaya is known as the famous travelling place in Thailand for both Thais and foreigners, Pattaya was also ranked to be the one of twenty cities where foreigners should purchase their second home. Statistically, 90% of power outage results from distribution system (L.Goel and Yan Ou., 1999,pp. 43-53). Hence, the continuously expanding of Pattaya leads reliability of power distribution system to become more important as stability of the system becomes a vital element to support almost all business activities.

This research studies all related elements of power interruption in Pattaya area in order to identify main factors to be focused on for improving the reliability of power distribution system by using scenario analysis as the methodology and reliability indexes of SAIFI and SAIDI as the core criteria for evaluation.

THEORY AND RELATED WORK

Related works

Previously, there are several works studied on reliability of electrical distribution system in many aspects. Some of which emphasize impact and the factors caused electrical failures while others highlight on how to measure reliability efficiently.

(Sand, K. Kjolle, G. Bilberg, J., 1989) studied the relation of reliability and planning in expansion of distribution system which has the purpose to improve the effectiveness of power distribution system.

(Roberto C. Lotero and Javier Contreras, 2011) presents an evaluation of a multistage optimization model for distribution systems expansion planning. The model aimed to find optional solutions in addition to the optimal one to help the decision maker analyzing and choosing solution from a pool of alternatives.

Apart from these there are varieties of works focused on the factor which cause the power outage such as modeling weather related failures of overhead distribution line (Yujia Zhou, Anil Pahwa, Shie-Shien Yang., 2006), analysis of animal related outage in overhead distribution system (Min Gui, Anil Pahwa, Sanjoy Das., 2009), etc.

Reliability Index

There are several reliability indices such as availability, Loss of Load Probability (LOLP), Expected Energy not Served (ENS), etc. However, for the purpose of determined the reliability of power distribution system which impact the end user, the reliability indices being used needed to be directly perceived by the customers. This research, therefore, use SAIFI which represent the number of interruption and SAIDI which state the duration of interruption to measure the reliability as they are reflect the impact of power interruption to the customers. Moreover, SAIFI and SAIDI are claimed by many researches to be the effective index that cover almost all the information needed as reliability index and also be the index that PEA used to measure the reliability of its power distribution system (Jamnarn Hokierti, 2004, Al-Muhaini, M., Heydt, G.T. and Huynh, A.,2010, Heydt, G.T.,2010 and Billinton, R. and Allan R.N., 1994).

Scenario Analysis

Scenario analysis is a method to predict the possible future outcomes by construct several alternative scenarios based on the idea of historical data and uncertainty of what possibly happen in the future (Aaker, David A., 2001 and Bea, F.X., Haas, J., 2005).

Scenario analysis highly benefit in finding the effective way to prevent power interruption event in the future as it can create several alternative scenarios. For this paper, the input data

based on historical data collected from database of PEA from 2007 to 2012. The test is operating by imposed the constraint which is the condition or factor to be focused in each case. The results advantaged in solving the problems and making plans in order to prevent electrical failure to reoccur.

METHODOLOGY

Descriptive Statistics

From the database of PEA, Pattaya consist of 6 substations with 50 feeders in total confronted power interruption from 2007-2012. According to historical data, the frequency of power interruption during studied period is 2,653 times which calculated average SAIFI and SAIDI to be 4.23 and 100.7 respectively. Although the number of power outage is fluctuated each year, there's no sign of decreasing in the number of power interruption. The most recent year, 2012, is the year with highest number of power outage at 592 times. In the past 6 years, Jomtien substation and feeder PYN-01 faced power interruption the most at 859 and 253 times respectively.

Causes

From PEA data base, the factor caused power outage can be divided into 11 factors as represented in table 1. During the studied period, the factors influenced the failure the most are animal, three and instruments at 804, 568 and 474 times respectively.

Table 1: Factor caused power outage

No.	Cause	Frequency	(%)
1	Overload in Power Supply	2	0.08%
2	Tree	568	21.41%
3	Human	20	0.75%
4	PEA's Officer	17	0.64%
5	Natural Disaster	117	4.41%
6	Vehicle	67	2.53%
7	Foreign Matter	45	1.70%
8	Environment	259	9.76%
9	Animal	804	30.31%
10	Other	280	10.55%
11	Instrument	474	17.87%
	Total	2653	100.00%

Source: PEA database from 2007-2012, Pattaya area

Seasons and Climates

Intuitively, power interruption should somehow relate to power outage event. However, according to historical data, there is no correlation between them as the electrical failure events occurred in the normal weather as much as 64.91%. The result is confirmed by looking at the month with highest power outage rate which is in May lying in summer instead of the month lying in changing season period which normally vary in climates.

Table 2: Relationship between frequency of power outage, seasons and climates

Season	Month	Rain	Rain with thunder	Rain and Windy	Windy	Foggy	Normal	Total
Winter	November	2	24	2	16	9	162	215
	December	2	1	0	0	1	144	148
	January	8	6	7	9	12	147	189
	February	16	31	5	5	3	141	201
	Total	28	62	14	30	25	594	753
Summer	March	10	46	18	16	12	139	241
	April	10	37	26	9	11	105	198
	May	7	71	18	10	9	168	283
	June	13	47	32	12	10	130	244
	Total	40	201	94	47	42	542	966
Rainy	July	10	22	24	17	7	170	250
	August	9	21	22	8	14	161	235
	September	34	47	19	6	17	124	247
	October	11	28	14	10	8	131	202
	Total	64	118	79	41	46	586	934
Grand Total		132	381	187	118	113	1,722	2,653

Source: PEA database from 2007-2012, Pattaya area

Scenario analysis

In order to create the scenario, the data related to power failure has been grouped into three interested features in terms of (i)causes created the power failure (ii)substation and (iii)feeder. In addition, the uncontrollable factors, which are natural disaster, environment, and others, have been eliminated from the test to comply with the purpose of planning to prevent power outage to reoccur in the future.

Six alternative scenarios have been generated to compare the effectiveness of power outage prevention on each focused factors.

- ➢ First scenario : prevent by focusing on element which cause power interruption
- ➢ Second scenario : prevent by focusing on substation
- ➢ Third scenario : prevent by focusing on feeder
- ➢ Fourth scenario : prevent by focusing on substation together with element which cause power interruption
- ➢ Fifth scenario : prevent by focusing on feeder together with the element which cause power interruption
- ➢ Sixth scenario : prevent all controllable factors

In each scenario from no.1-5, the considering factors are those with the higher frequency of power outage than the average value of all electrical failure events in that scenario. For scenario no.6, all controllable factors are removed in order to create the benchmark case which prevent the power interruption by eliminated every possible factors that can be prevented.

RESULTS

Excluding the benchmark case (scenario no.6), the result of the best case is mixed.

- ➢ Judging by SAIFI : the best case is scenario no.2, preventing at substation, which reduced SAFI by 68% to be 1.36.
- ➢ Judging by SAIDI : the best case is scenario no.1, preventing at element caused power interruption, which reduced SADI by 64% to be 36.79.

On the other hand, the worst outcome is scenario no.5 which stated that SAIFI and SAIDI decrease only 44% to be 2.36 and 56.35 respectively.

For the benchmark case, scenario no.6, which in fact is the best one if compared to all scenarios as it removed every possibility that can be prevented, the result showed SAIFI and SAIDI to reduced by 80% and 74% respectively. However, the result also implied that even preventing all controllable factors the power outage event still exist as can be seen from SAIFI and SAIDI value are both not zero

Table 3: Results of alternative scenario**s**

Description	SAIFI	Reduction of SAIFI (%)	SAIDI	Reduction of SAIDI (%)
Scenario no.1 : Focus on cause	1.47	65%	36.79	64%
Scenario no.2 : Focus on substation	1.36	68%	37.22	63%
Scenario no.3 : Focus on feeder	2.33	55%	47.12	53%
Scenario no.4 : Focus on substation and cause	1.91	55%	47.45	53%
Scenario no.5 : Focus on feeder and cause	2.36	44%	56.35	44%
Scenario no.6 : Focus on substation, feeder and cause	0.84	80%	26.01	74%

CONCLUTION

Reliability of power distribution system is the key factor to be concerned to improve in line with the economic growth. Planning to prevent the power interruption is one way to improve reliability. This paper applied scenario analysis to assist the power management and planning in operational term by focusing on the factor that should be effectively prevented. The result stated that the benchmark case, eliminated all controllable factors, yield the best outcome by decreased SAIFI, SAIDI by 80% and 74% to be 0.84 and 26.01 respectively.

REFERENCE

1. Aaker, David A. "Strategic Market Management". New York, John Wiley & Sons, 2001.

2. Al-Muhaini, M., Heydt, G.T. and Huynh, A. "The Reliability of Power Distribution Systems as Calculated Using System Theoretic Concepts". IEEE conference publication, Power and Energy Society General Meeting, 2010.
3. Bea, F.X., Haas, J. 2005. Strategisches Management. Stuttgart, Lucius & Lucius.
4. Billinton, R. and Allan R.N. "Reliability Evaluation of Power System", 2nd ed., USA, Plenum Press, 1994.
5. Heydt, G.T. "The Next Generation of Power Distribution Systems". IEEE transaction on smart grid, Volume 1, Issue no 3, 2010.
6. Jamnarn Hokierti. "Collaborative project Kasetsart University with PEA studied on reliability in electrical power system". Department of Electrical Engineering. Faculty of Engineering at Kasetsart University, 2004.
7. L. Goel and Yan Ou. 1999. Reliability Worth Assessment in Radial Distribution Systems using the Monte Carlo simulation technique. Electric Power Research. vol. 51, pp. 43-53.
8. Lotero, R.C., Contreras, J.,2011. Distribution System Planning With Reliability. IEEE Transactions on Power Delivery, vol. 26, pp. 2552 – 2562
9. Min Gui, Anil Pahwa, Sanjoy Das.,2009. Analysis of Animal-Related Outages in Overhead Distribution Systems With Wavelet Decomposition and Immune Systems-Based Neural Networks. IEEE Transactions on Power Systems, vol. 24, pp. 1765 – 1771
10. Sand, K. Kjolle, G. Bilberg, J. 1989. Reliability aspects concerning distribution system expansion planning. 10 th International Conference on Electricity distribution CIRED, Vol. 6, pp. 530-534
11. Yujia Zhou, Anil Pahwa, Shie-Shien Yang., 2006. Modeling Weather-Related Failures of Overhead Distribution Lines. IEEE Transaction on Power System, vol. 21: 1683 – 1690

AN INTERNATIONAL STRATEGY IN SOUTHEAST ASIAN MARKETS FOR TAIWANESE BANKS

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ABSTRACT

Overbanking situation and following the customers are the main reasons for local banks going global. ASEAN is a potential market for Taiwanese banks due to the increasing trading and investing of Taiwanese firms and a rapid growth in banking sector in this region. The purpose of this study is to analyze the overseas expansion development of Taiwanese Banks in Southeast Asian (ASEAN) region. Five-Force model and SWOT approach are used to analyze the competiveness of banking industry and banks' pros as well as cons once enter in ASEAN. In addition, Cross-selling also is adopted efficiently to take advantage of customers' base in region. By establishment of representative office and branch, Taiwanese bank enters in ASEAN markets to fulfill a strong network in region. Moreover, the analysis results in case study also show that the close connection of capability, customer and geography is the core factor of success of regionalization. By sharing and supporting resources, technology inside hub, E.SUN Bank is able to keep its milestone is providing excellent service at lower cost and less operations risk in region.

Keywords: Over-bank, Follow customers, International strategy, Cross-selling, E.SUN Bank.

INTRODUCTION

Due to the rapidly changes in financial industry, the international economics is getting more complicated. The 2000s decade is the tsunami era of financial industry thanks to the financial crisis in US in 2008 with the bankruptcy and merge & acquisitions of a series of big

American Banks and the European debt crisis effecting to the development of global economic. Thus, the big issues for medium banks are enduring and developing in such situation. The common solution is going global to catch the opportunities and benefit in foreign countries which are unfulfilled financial services.

E.SUN commercial bank, with 20 years developments, is a young-bank in Taiwan's banking industry. However, E.SUN has some significant achievements of its improving services and expansions. E.SUN Bank got award of Best service in Taiwan in 2009 and kept its rank up to date. E.SUN first overseas expansion is establishing branch in Los Angeles, America (2000) and in Hong Kong (2002) and Representative Office in Hochiminh City, Vietnam and in Dongguan, China. During the financial crisis, E.SUN Bank has prolonged its expansion in Asian market by upgrading its Representative Office in Dongguan to branch, setting up Singapore branch and getting approval to open branch in Cambodia in August, 2012.

The purpose of this study is used to analyze the international strategy of E.SUN Bank in ASEAN region. Information in this study is come from interviewing the authorized persons in E.SUN and collecting secondary data. To analyze the overseas expansion development of E.SUN Bank in Southeast Asian (ASEAN) region, this study proposes an adaptive Five-Force model and SWOT approach capable of dealing with five main issues: 1) The reasons of going global of E.SUN Bank; 2) The markets E.SUN bank should go and reasons; 3) Kind of service E.SUN Bank should provide in its overseas business; 4) Risk management at E.SUN Bank when going global; and 5) The fields E.SUN bank should improve to develop and get more benefits in overseas business.

The rest of the paper is organized as follows. Section 2 reviews the conventional methods relating to strategy, going global, banking industry and Southeast Asian (ASEAN) region to consolidate and create a base - platform for this research. Section 3 presents the research methodology. Section 4 conducts a case study for analyzing E.SUN's strategy, market segment and risk management process in ASEAN markets. Finally, section 5 concludes the study and suggests future research.

LITERATURE REVIEW

Banking sector played an essential role in the global economy because it has access to the capital, the technological capabilities, and the international network to facilitate these activities (Thunman (1992); Jayawardhena and Foley (2000); Malul et al., (2009)). The business sector is monitored by banks through the evaluation, pricing, and credit-granting functions (Arteaga et al., 2007). In the 1970s, banking industry was strong internalized since the rapid increase in international trade. The talk is of global banks comes out with the rapid expansion of global

networks (Glover, 1986). In mid of the 1990s, international banking activities have reached a historical peak thank to an enhancing in cross-border merges (Berger et al. 2007).

There are two different aspects of internationalization (Drogendijk and Hadjikhani, 2008). The first aspect refers to the exchange in terms of import and export of banking services and transactions in foreign currency. The second one is related to the strategy of banks when internationalizing (Vasiliadis, 2009). M.A. Hitt (2011) defined international strategy "is a strategy through which the firm sells its goods or services outside its domestic market". This means that the firm will expand its presence in overseas to catch the new opportunities for growth and development. Moreover, the firm can access to new resource and take advantage from economies of scale by going global.

Raymond Vernon (1996) mentioned about international diversification which means that the firm produces and does innovation for its product at home country to serve not only domestic market but also export in other countries. By implementing international strategy, the firm can extend its product life-cycle and utilize the cost for R&D. In context of globalization with increasing competitiveness and technology development, a number of firms go abroad is rising significantly to save cost, strengthen customer base and capture new market segment. One of the well-known models for internationalization was developed by Johanson and Vahlne (1977) who described foreign-market entry as a learning process (see Fig. 1.).
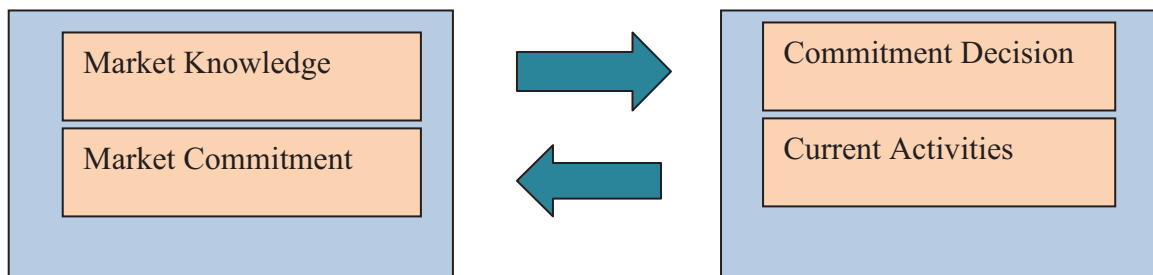
Fig.1. Models for internationalization of Johanson and Vahlne

The firm makes an initial commitment of resources to the foreign market and gain local market knowledge about customers, competitors and regulatory conditions. On the basis of foreign market knowledge, the firm is able to evaluate its current activities, the extent of its commitment to the market and the opportunities for additional investment. It then makes a subsequent resource commitment, perhaps buying local distributor or invest in a local factory which allows it to develop additional market knowledge and become an effective competitor in foreign market. As shows in Fig. 2, M.A. Hitt (2011) has developed framework of Opportunities

and Outcomes of International Strategy to describe the detail of all steps for internationalization with various choices and outcome of strategic competiveness.
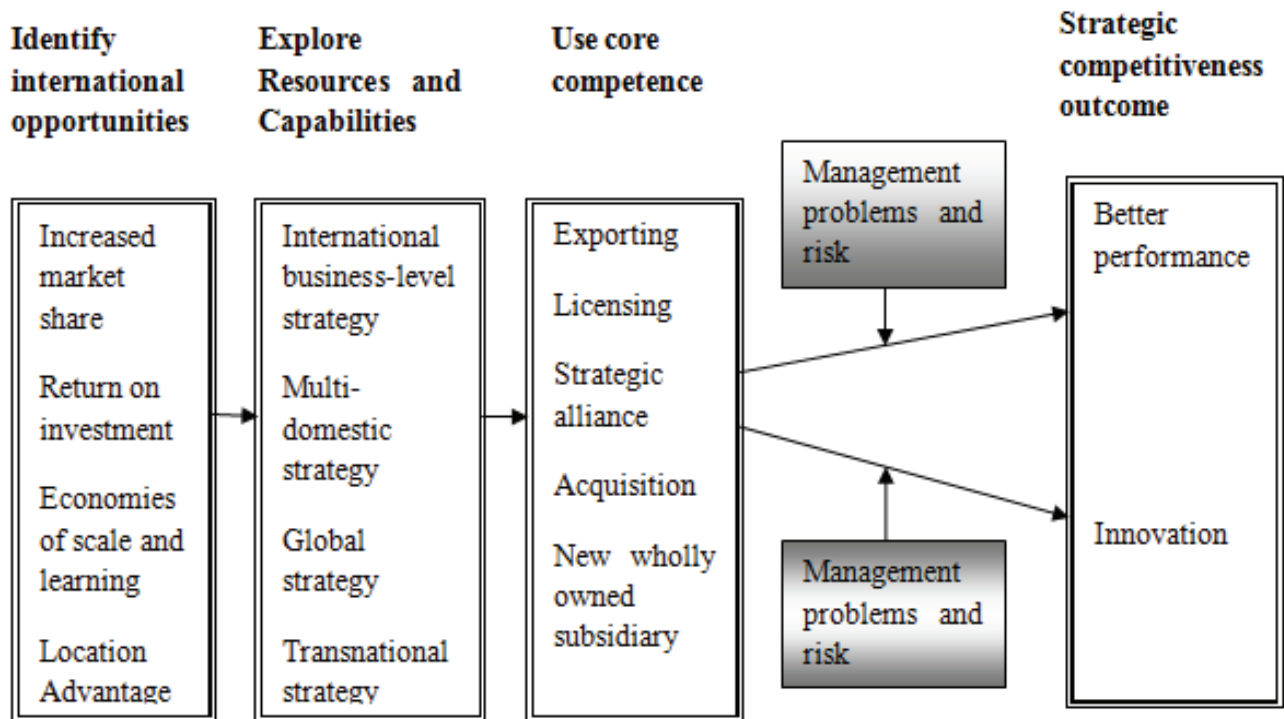
Fig.2. Framework of Opportunities and Outcomes of International Strategy

Based on the foreign market knowledge, the firm is able to identify its opportunities when enter in this market. It then chooses one of four of strategy in compliance with its resources and capabilities. Consequently, the firm determines the method of approaching to foreign market entry by exporting, licensing, strategic alliance, acquisition or new wholly owned subsidiary based on its core competence and have to plan for managing problems and risks in this market. The firm at last is able to evaluate its effective on doing overseas business via its competiveness outcomes: better performance and/or innovation.

OVERVIEW OF BANK INDUSTRY IN ASEAN AND E.SUN BANK

Banking industry in Southeast Asian (ASEAN) Region

ASEAN is currently one of the most dynamic and fastest-growing regions in the world economy including 10 countries: Vietnam, Laos, Cambodia, Thailand, Singapore, Philippines, Brunei, Myanmar, Indonesia and Malaysia. Despite the global financial crisis, banking sector of ASEAN in recent years still has achieved good performance in growth of bank's assets and credit. In additional, the region's GDP is expected to triple to US$3 trillion by 2017 relative to a

decade ago. Economic expansion is expected to be sustained at a rate of 5.8% in the next five years, significantly outpacing global growth. As shows in Table 1, the total assets of the Indonesian banking system were at US$340 billion in 2010, higher by 18.8% from a year earlier or 105.0% from 2005, as per Bank Indonesia data. By end-November 2011, total banking assets in the country reached US$392.4 trillion. Commercial banks dominate the Indonesian banking industry with their total assets comprising 98% of the country's total banking assets (Bank Indonesia, Bangko Sentralng Pilipinas, Monetary Authority of Singapore, Bank of Thailand (2011)).

Table 1: Bank's assets in some ASEAN markets

Country	US$ billion
Indonesia	340
Philippines	158
Singapore	609
Thailand	391

In the Philippines, the total assets of the banking industry stood at US$158 billion in 2010, with 47% being in the form of loans. The share of the financial sector in the banking sector's loan portfolio was the highest for the year at 21.7%, followed by real estate-renting-business activities at 15.1%. Moreover, both agricultural and manufacturing sectors held 12.2% each of Philippine banks' total loan portfolios. Meanwhile, total liability of the country's banking industry stood at US$139 billion of which 84% were deposit liabilities.

Besides that, Singapore's total banking assets was valued at US$609 billion in 2010, rising 10.7% from 2009. Loan portfolio accounted for 41% of total assets, while 30% were amounts due to banks. Deposits comprised 55% of total liabilities. Meanwhile, Thai commercial banks' total assets at the end of 2010 stood at US$391 billion, up 13.2% from the previous year. About 63% of bank assets were loans and 15% were in securities investment. About 70% of the Thai banks' loan portfolios were in corporate loans while the remainders were in consumer loans. On the other hand, total liabilities was valued at US$357 billion in 2010, and 69% of these were in deposits. In additional, Vietnam and Indonesia also listed on the top 10 countries with highest

assets growth of banking sector at growth rate 33.92%, 30.21% respectively described as Fig. 3.(Database banker,2012).
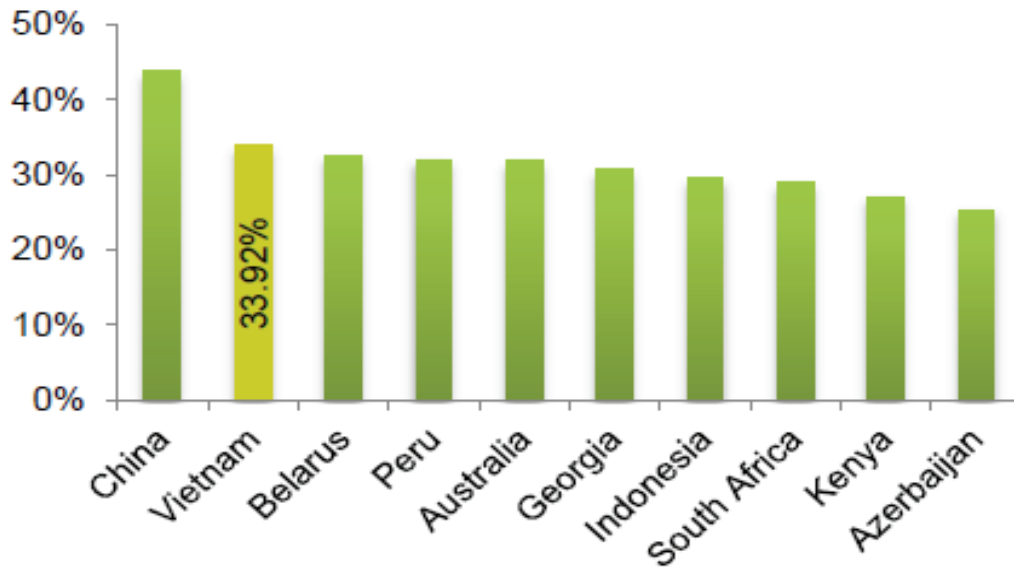
Fig.3. Top 10 countries with highest asset growth of banking sector 2012

For ASEAN economies, the bank credit to GDP ratio for 2010 ranges from 22.5% in Cambodia to 135.8% in Viet Nam (see Fig.4)-(Development Indicators, World Bank). There was positive annual growth in bank credit in many ASEAN economies—such as Malaysia and Thailandwith average growth rate at 7.8% and 4.6%, respectively during the period of 1960-2010. Brunei Darussalam, Cambodia, Lao PDR and Viet Nam economies has recorded double-digit average annual growth rates include since 2000. In Indonesia, the outstanding size of bank credit by commercial banks surged between end-2009 and end-2010 by 22.8% to US$196.5billion, and accelerated further by 21.6% year-to-date to US$239billion at end-November 2011, according to Bank Indonesia data. The sharp rise in bank credit in Indonesia is largely due to aggressive bank lending to micro enterprises and small-and medium-scale enterprises (SMEs).
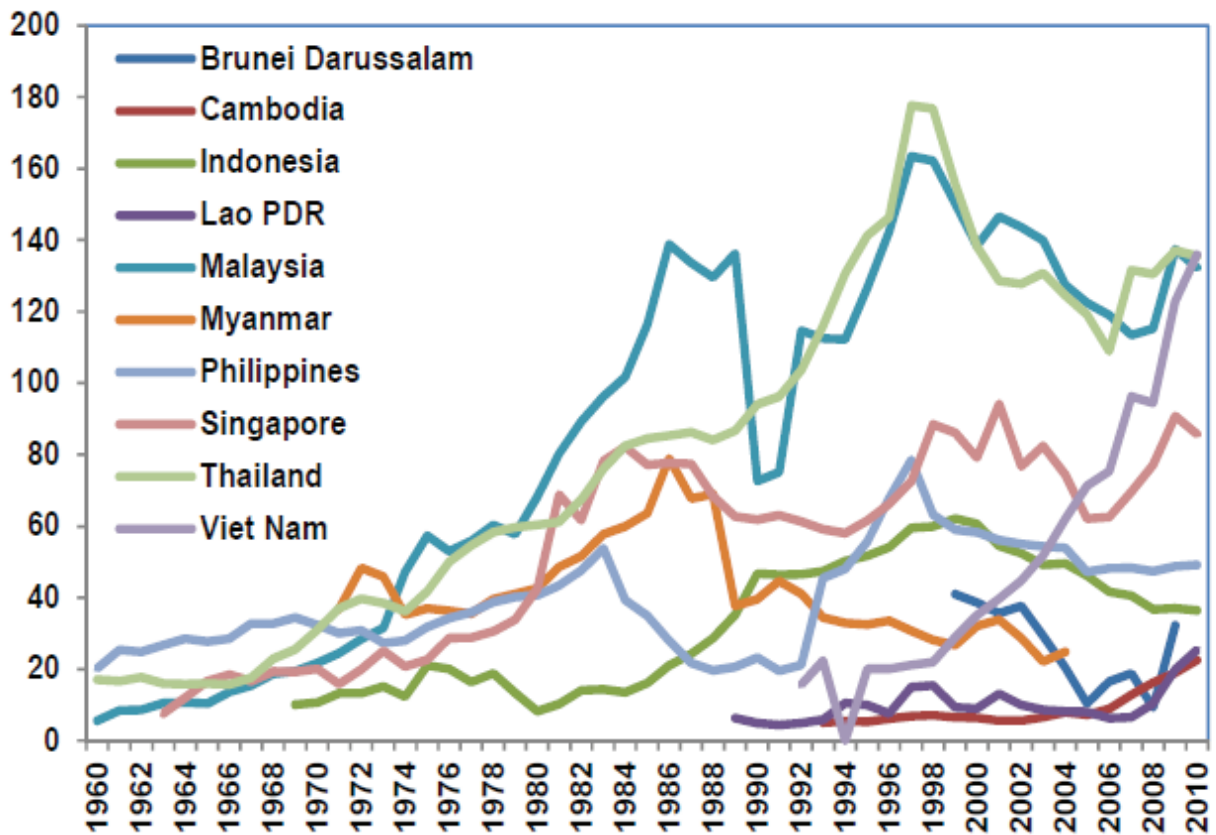
Fig.4. Bank Credit in the ASEAN region period 1960-2010 (percent of GDP)

Overview of E.SUN Bank

E.SUN Commercial Bank was established in 1992 with the purpose is creating a first-class bank with three key the features as following: foundations of sustainable growth, union banking network marching towards a broaden future and be an esteem enterprise with achievements. E.SUN believes that "Channel is king", as the network serves as the foundation for customer service and is the decisive factor in business development. In 2011, E.SUN Bank acquired Chu Nan Credit-Cooperative Association helping the Bank to expand its network to 132 branches eventually. E.SUN Bank is keeping improving and developing overall financial services. The position of the highest quality of service as the advantage of corporate brand, making the name of E.SUN is equivalent to the best quality of service, creating E.SUN's eternal value, and maintaining the irreplaceable advantage. As long-term strategy, E.SUN Bank will bring toward to the international, and achieve "Taiwan's E.SUN Today will become Global E.SUN Tomorrow".

E.SUN Bank is organized in 13 divisions which are: Corporate Banking, Consumer Banking, Wealth Management, Treasury, Credit Card and Payment Finance, Risk Management, Customer Service, General Affair, Legal, Human Resources, Credit Review and Management, Accounting and Information Division. In which, the main revenues of bank are come from the following operations: corporate banking and consumer banking. E.SUN continues to strive to provide innovative electronic banking services and enhanced functionality to meet the financial service needs of its customers. E.SUN Bank's milestone is building its strong brand name through the best services for customers. E.SUN has achieved many awards in domestic as well as international institutions and magazine demonstrating for its quality services.

RESEARCH METHODOLOGY

In this section we describe the Five-Force model and SWOT approach to analyze the international strategy of E.SUN Bank in ASEAN region

Five-Force model

SWOT approach

CASE STUDY

Five-forces analysis of banking industry
The five-force model is adapted to analysis the competitiveness in banking industry in ASEAN (see Fig.5)

Fig.5. Five-force model analysis

Threat of new entrants

Since banks play an important role and have huge effects to national economy, there are many strict requirements to establish as well as tight regulations to operate a bank especially after the financial crisis in 2008. The initial and important requirement to enter in banking sector is capital which does many things and is legalized by each country based on the international regulation. In general, there is a high capital requirement for new entrant in banking industry. In Singapore, domestic banks have to satisfy the capital level at US$1.168 billion to establish a new one while minimum capital requirement for foreign bank branches is US$155.73 million. There also have the different requirement for each type of bank, for instance, a universal bank must have a minimum capital of US$115.05 million while that of a commercial bank is US$54.81million in Philippines (see Table 2)

Table 2: Minimum capital requirements of banks in ASEAN

Unit: million

Country	Domestics Bank	Subsidiaries of foreign bank	Foreign Bank Branches
Indonesia	US$333.33	US$333.33	New entry - Not allowed
Philippine	Universal Bank: US$113.05 Commercial Bank: US$54.81	Universal Bank: US$113.05 Commercial Bank: US$54.81	Universal bank: US$34.25 Commercial Bank: US$4.79
Vietnam	US$150	US$150	US$15
Singapore	US$1168	US$1168	US$155.73
Thailand	US$166.44	US$133.15	assets: no less than US$99.86

Moreover, there are some specified regulations to dismiss and control risks in operating. As shows in Table 3, the regulation on exposure limits related parties indicated the maximum asset of related parties is allowed exposure on bank's capital fund. In Malaysia, Philippines and Singapore, supervisors provide a uniform risks concentrations limits to related parties of up to a maximum of 25% of bank's capital fun. Meanwhile, in Thailand, a bank is allowed to exposure limit of 5% of its tier 1 capital which should not exceed 50% the related parties' equity or 25% of its total liabilities. Besides that, there are some requirements of personnel, plan of business, Information System... Every member of the board of directors has to be checked and verified capability by the authorized competent in country. The banks have to prove the effectiveness of business plan, to demonstrate the security of IT system able to do transactions…Thanks to many rigorous requirements, the threats of new entrants in banking industry in ASEAN are quite low.

Table 3: Asset Quality Regulation in Relation to Large Exposure Limits

Country	Related Parties (as a % of capital)
Philippines	25% of unimpaired capital and surplus
Singapore	25% of capital fund
Thailand	5% of tier 1 capital; 50% of equity of related parties; 25% of total liabilities of related parties (whichever is lower)
Indonesia	10%

The bargaining power of suppliers

The unique of banking industry is the biggest supplier - Central Bank. Central Bank is responsible to set the Monetary Policy to promote the objective of maximizes the employment, stable price and moderates the long-term interest rate for a substantial growth economy. In addition, the Central Bank has supervisory and regulatory authority over a wide range of financial institutions and activities in country through setting up or adjusting Laws, Decrees, and Regulations for financial institutions in compliance with the economic conditions. Central Bank also provides the loans for commercial banks and plays the role of "lender of last resort" who is able support commercial banks which are in financial trouble to avoid the bad effects to economic.

There are some common tools which are used to manage risk and maintain liquidity in system. Different tools have their own functions and effects to system. Indonesia has used Short-term funding; Intra Liquidity/ Overdraft; Deposit to maintain the available of daily liquidity and guide market rate while Philippine has utilized deposit and Rediscount facility to Meet banks' unexpected liquidity needs and as a signal monetary policy stance (Table 4.4). With the full of power to handle economy of nation, the Central Bank make the power of supplier in banking sector is very high.

The bargaining power of consumers

Customers are taking greater control of their banking relationships. They are switching banks, changing their behavior and demanding improvements. Report of World Retail Banking 2012 showed that the loyalty of customers with their banking is quite low. In some countries such as Vietnam, Singapore and Philippines, customers intend to change their banking in next 6 months with the likely to leave is 69%, 53% and 44% respectively (see Fig.6)

	Global Average (40%)	Global Average (9%)	Total Unsure or Likely to Leave (%)
China	70%	12%	82%
Taiwan	76%	4%	80%
Vietnam	54%	15%	69%
Saudi Arabia	52%	15%	67%
UAE	44%	20%	64%
Germany	29%	33%	62%
India	47%	13%	60%
Hong Kong	56%	4%	60%
Austria	25%	34%	59%
Spain	45%	12%	57%
Mexico	45%	11%	56%
Brazil	48%	7%	55%
Japan	52%	2%	54%
Argentina	43%	10%	53%
Singapore	47%	6%	53%
Portugal	47%	4%	51%
Turkey	43%	8%	51%
Czech Republic	43%	7%	50%
Italy	45%	5%	50%
Poland	40%	7%	47%
Switzerland	24%	22%	46%
Sweden	38%	7%	45%
Philippines	41%	3%	44%
Russia	37%	6%	43%

Fig.6. Customers' likelihood changes their primary bank in the next 6 months

There are many factors affecting customers' trust and leave their banks such as: quality of service, fee, convenient location… as well as recommendation by friends, colleague. . In which, quality of service emerges as the leading reason customers leave their banks. More than half of customers (53%) are willing to leave their banks because of the quality of service they received (see Fig.7).
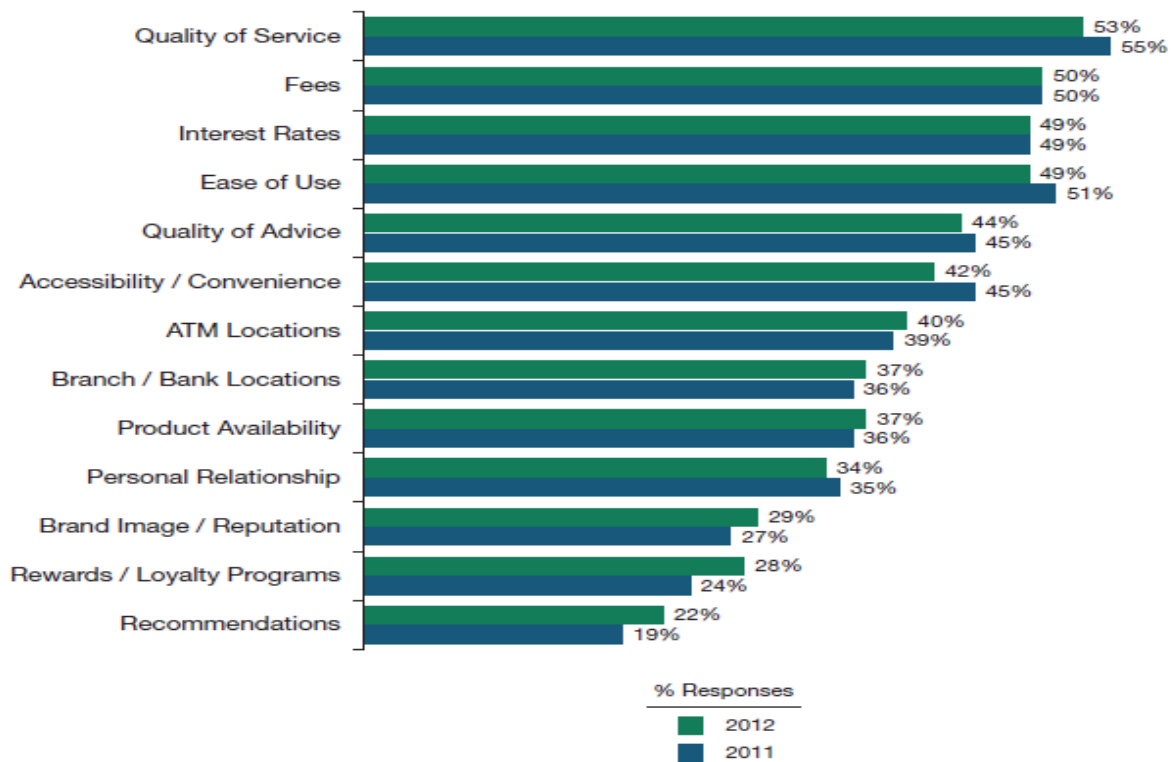
Fig.7. Factors that affect customers leave a bank (%) 2011-2012

Asia-Pacific region is the lowest-level of satisfaction in banking service. Thus, customers likely intend to change their banks to get better services (see Fig.8). Because of the low loyalty and un-satisfied services, the power of consumer in banking industry in Asia-Pacific as well as ASEAN region is significantly high. In response, banks need to reevaluate their assumptions and fundamentally change how they interact with their customers. They need to embrace change by giving their customers greater flexibility, choice and control, and by reconfiguring their business models around customer needs.
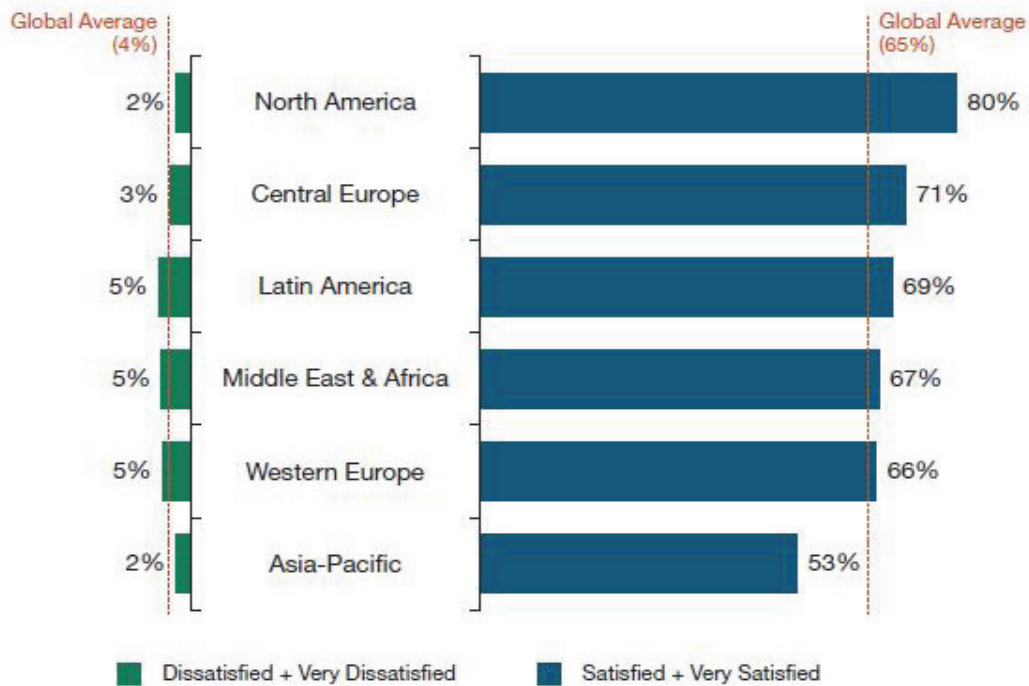
Fig.8. Customer satisfaction with primary bank (%) by region in 2012

Threats of substitute products/ services

The development of insurance industry with many big firms has competed to banking services to get the deposit of customers via a long-term investment of insurance products. As show in Table 4, there was a high growth rate of insurance premium in 2010 in ASEAN countries. Indonesia was the fastest growing market at growth rate of 54%.

Table 4: Growth rate of insurance firms in some ASEAN countries 2010

Country	Name of insurance firms	Growth (2010)	
Malaysia	Great Eastern Life	15.40%	15.70%
	Prudential	26.90%	
	ING Insurance	17%	
	AIA	2.70%	
	Hong Leong	14.10%	

Country	Name of insurance firms	Growth (2010)	
Indonesia	Prudential UK	30.80%	54%
	Allianz Life Indonesia	95%	
	AXA Mandiri Financial Services	163.90%	
	Bumkiputera 1912	12.20%	
	Bringin Jiwa Sejahtera	330.90%	
Thailand	AIA	5.40%	11.20%
	Bangkok Life	40.80%	
	Muang Thai Life	27%	
	Thai Life	4.20%	
	Siam Commercial NY Life	0.50%	
Singapore	Prudential UK	-0.40%	20%
	Great Eastern Life	33.60%	
	NTUC Income	31.20%	
	AIA	28.90%	
	Swiss Life	17%	

The financial crisis in 2008 is one of the reasons of the increasing sales of insurance life products because consumers have lost the confidence in banking services. Taking this advantage, insurance firms have tailored more flexible services to serve customers at high convenience and satisfaction a range of product propositions compliance with their needs. Because of the development of insurance firms, there are more choices in financial services for customers in ASEAN region. However, the presence of Financial Holdings Companies has helped banks to reduce the threats of substitute services. In particularly, the establishment of FHCs will make Bank, Insurance Company and Securities Company become its subsidiary. Afterward, the cross-selling is adopted to meet the demand of customers and gain the effective of cost-cutting by take

advantage of the prior network customer. For instance, Cathay Financial Holding Companies has performed very well in cross-selling which is a key part of its strategy to provide a one-stop financial service including bank, insurance service. Therefore, threats of substitute services in banking industry can be evaluated at Medium level due to the trend of establishment Financial Holdings.

Rivalry among existing competitors

There are a thousand of banks and branches in region try to provide the flexible services in Loans, Deposits, and Credit card… to satisfy customers' needs. There are 711 banks in Philippines in which, Rural Bank and Cooperative Bank are more than 600 banks supporting for the development of agriculture and small business in local. With 167 banks, Singapore is rank at 2nd and is the central of finance in region. Most of foreign banks have stand there as a bride for them to access in ASEAN. There are three Singapore banks including: DBS Bank, OCBC Bank and UOB Bank list on the Top of Four regional big banks beside Maybank of Malaysia. As the most developed country in banking industry, there are diversified services in Retail Banking, Corporate Banking and Investment, provided not only in Singapore but also in region and international market.

Moreover, the competitive in ASEAN region is higher due to the presence of large international banks such as Citibank, Hongkong and Shanghai Bank (HSBC), Standard Charter Bank and Australia and Newzeland Bank (ANZ). Foreign banks are currently competed strongly to local banks and increased market share by their reputation, experience and strengthen strategy. For instance, HSBC in Singapore has achieved pre-tax profit of almost US$600 million for 2011 - an increase of 14 percent on-year and expected to get annual profit target of one billion US dollars by 2016.(13)In additional, banks now are focusing more on development of their products to make it differentiation and meet the demand of customers. Thus, the intensity of competition among existing banks in ASEAN region obviously is very high.

In summary from the Five-Force Model analysis, banking industry is unfavorable to enter since most of the forces scored are high (see Table 5).

Table 5: Five-force analysis of banking industry in ASEAN

Forces	Level	Favorable (+)/ Unfavorable (-)
Threat of new entrants	Low	(+)
The bargaining power of suppliers	High	(-)
The bargaining power of consumers	High	(-)
Threats of substitute products/ services	Medium	(+)
Rivalry among existing competitors	High	(-)
Summary	High barrier for entrant High competitive	(-)

SWOT Analysis of E.SUN Bank in ASEAN
Strengthen

As its mission and strategy, quality of services is the key factor to help E.SUN succeed in overseas expansion. E.SUN will take advantage of its brand-awareness and reputation in Taiwan to access in foreign markets. By integrating with E.SUN Financial Holdings, there are more resources, capital and service for E.SUN Bank implements and develops. For instance, E.SUN can focus more on Wealth Management including Mutual Funds, Ban assurance services when goes abroad.

Thanks to a huge investment in IT development, E.SUN currently is running the EFS program on whole system including foreign branches to manage operation risks and increase working productivity efficiently. Moreover, the very important factor building E.SUN's success is human resource. There is a talent team leading with high passion and enthusiastic leading firm

on right track of development. E.SUN also provides good training programs for all staff clearly understand its corporate culture. Staffs feel E.SUN is their big family and dedicate to make it bigger. The current logo of E.SUN Bank, a friendly and funny fat cat, also is designed by their staff. Positioning at high quality services, supporting by E.SUN financial Holdings, delighting human resource and strongly developing IT system are key strengthens of E.SUN Bank to expand overseas.

Weakness

E.SUN is a young bank only with 21 years of development and does not have much experience in global expansion. Thus, it may take long time for E.SUN Bank to plan, implement and succeed in overseas market. Comparison with other big Taiwan's, E.SUN's asset and capital is at medium level. E.SUN is rankedat Top 13 bank in Taiwan and Top 313 bank in world. Thus, there are some markets E.SUN is not able to enter since their requirements for foreign bank entry. For instance, only allowsforeign banks which is at Top 5 of its parent country establish branch in Philippines while Indonesia's requirement for foreign bank branch isTop 200 bank in world. At present, the reputationof E.SUN's service still is broaden inTaiwan. In global market, brand-awareness of E.SUN is very small and it looklike E.SUN is starting at first step to build its domestic image become international brand. Thus, it is quite difficult for E.SUN at first presence at overseas markets.

Opportunities

There are large opportunities for E.SUN to earn profits in overseas expansion thank to providing financial service for Taiwanese companies doing business over the world. Nowadays, there are more Taiwanese firms expanding to foreign markets especially in China, Asia Pacific including ASEAN countries such as: Vietnam, Cambodia, Singpapore, Thailand... The sooner E.SUN operates at these foreign markets, the higher profit they can get from service fees, foreign exchange transactions and cross-border syndication loans.

In additional, banking services in developing countries in ASEAN region are not fullfilled and recently are evaluated at high growth rate. The majority of service is basis loan and deposit, there is a few of professional services for customers. For instance, Wealth Managerment and Investment Banking are quite fresh in Vietnam, Cambodia, Laos. The number of people still do not reach to banking service are accounted for more than 50% population in Indonesia, Vietnam. Beside that, there is a segment for people living at rural since most of banks are currently focusing on big cities. E.SUN also have opportunity to take advantage of foreign students styding at Taiwan to build high-quality human resource with lower cost for development at overseas markets.Thus, there are high potential profits might be explored through international expansions for E.SUN Bank.

Threads

As above analysis, there is a high competitive in banking sector in ASEAN region. Wherever E.SUN goes aboard, there is a tight challenge with many competitors including local banks, other big foreign banks such as Citi, HSBC, ANZ eventhough Taiwan's banks like: Fubon, Cathay and Sinopac. Entering into foreign markets, E.SUN Bank will deal with different culture, language and legal system. Thus, the potential of country risks such as: changing laws and regulation of banking sector, transforming in politics emperior... which can affect to E.SUN's operation and profit. Most of ASEAN countries, the governments have strictly restriction for entry of foreign banks. From this analysis, E.SUN Bank is obviously aware of its Strengthens, Weaks and Opportunities, Threads once expanding overseas, especially in ASEAN market (see Table 6).

Table 6: SWOT analysis of E.SUN in ASEAN region

Strengthens	**Weakness**
High quality service	Young bank
Support from E.SUN Financial Holdings	Medium sized
Human Resources	Little overseas expansion experience
Technology	
Opportunities	**Threads**
Increasing trading between Taiwan - ASEAN	Many competitors
Unfulfilled banking services	Different culture
Local staffs	Legal risks

Case analysis

Identify international opportunities

More than 30 years ago, Taiwan was a high economic development with mild inflation rate and low unemployment. There was an strictly policy for new entrants in financial industry as well as banking sector since financial system play the key role in the development of Taiwan's economic. Until the 1990s, Taiwan's government began to allow for new establishment financial

institutions and entrants of foreign banks in domestic market. Due to the opening market, the number of banks increases, and the phenomenon of overbanked in Taiwan came out. The average rate of return on equity (ROE) of banking sector dropped dramatically from 20.79% in 1990 to 2.09% in 2006 and 7.43% in 2007. The non-performing loans rose from 0.93% of total loans in 1990 to 8.59% in 2007.

The number of branches also is over-branched. There are 972 branches in Taipei in 2006. In particularly, there are 3.58 branches per square kilometer and 3.7 ones per 10,000 persons in Taipei which is higher than in Hongkong and Seoul. Thus, Taiwan banking industry has planned to reduce the number of branches in Taipei with detail target is: decreasing 35% to the number of 628 branches similar to Seoul in mid-term and at the end state lowering to 463 branches as in Hongkong (see Fig.9). Mr. James Chen evaluated "Taiwan banking industry is overbank; it's hard to get the fee from services in comparison with others developing countries in ASEAN". Thus, like the dilemma in "Blue Ocean", since the Taiwan banking market is full of competitors and less of profits, E.SUN Commercial Bank has to prepare and implement a global plan to find other opportunities in foreign markets. Expansion to international will be a strengthen foundation for the substantial growth of E.SUN Bank.
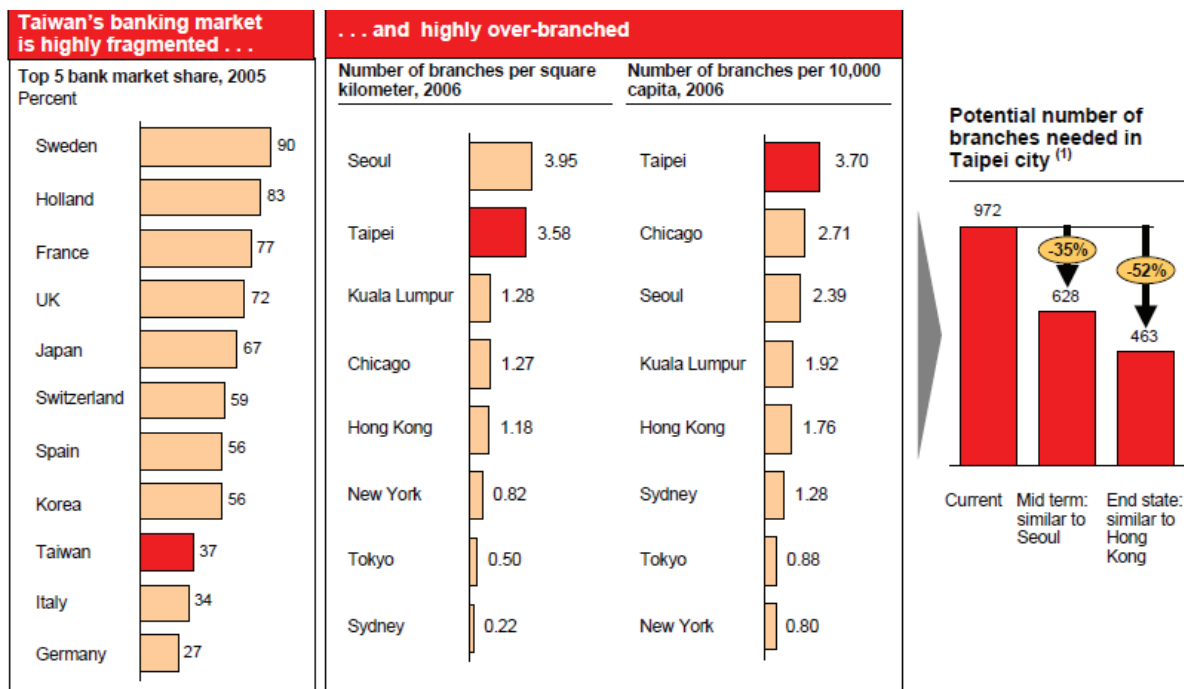
Fig.9. Taiwan is overbanked and over branches (2007)

"The increasing of trading between Taiwan and ASEAN in recent years will be the potential opportunity for E.SUN Bank in this region"– Mr. Dennis Chung said. The majority of Taiwan's trading partners are China, United States, Japan and ASEAN countries. As show in Table 7, the trading with ASEAN market is significant increasing during 2009 – 2012 period despite of the effect of financial crisis. The total amount of trading between Taiwan and ASEAN was increased from US$50,421 million in 2009 to US$89,743 million in 2011, with growth rate 77.98%. In September 2012, the trading amount in ASEAN is achieved at US$66,102 million and accounted for 15.45% of Taiwan's total trading. With the advantages of geographic, culture and trading history, the business between Taiwan and ASEAN markets keep increasing. Therefore, as service provider, E.SUN Bank needs to capture the revenue from serving trading transactions of Taiwan with these countries by its presence.

Table 7: Major trading partner of Taiwan (2009 – 2012)

Country	Rank	Amount (million US$)				Share (%)			
	Sep-12	Sep-12	2011	2010	2009	Sep-12	2011	2010	2009
Global	-	427,592	589,687	525,829	378,038	100	100	100	100
China	1	90,502	127,555	112,880	78,671	21.166	21.631	21.467	20.81
Japan	2	49,801	70,427	69,922	50,721	11.647	11.943	13.298	13.417
U.S	3	42,536	62,122	56,845	41,706	9.948	10.535	10.81	11.032
Hongkong	4	29,658	41,760	39,434	30,567	6.936	7.082	7.499	8.086
Singapore	5	21,103	30,238	19,732	13,423	4.935	5.128	3.753	3.551
Malaysia	8	10,860	15,493	13,643	8,613	2.54	2.627	2.595	2.278
Indonesia	11	9,460	12,265	10,530	8,410	2.212	2.08	2.002	2.225
Vietnam	12	8,178	10,871	8,816	6,908	1.913	1.844	1.677	1.827
Philippines	13	7,938	10,533	8,302	6,046	1.856	1.786	1.579	1.599

Country	Rank	Amount (million US$)				Share (%)			
	Sep-12	Sep-12	2011	2010	2009	Sep-12	2011	2010	2009
Thailand	14	7,825	9,378	9,117	6,508	1.83	1.59	1.734	1.722
Cambodia	51	508	664	487	336	0.119	0.113	0.093	0.089
Myanmar	72	167	207	171	137	0.039	0.035	0.032	0.036
Brunei	103	54	79	37	31	0.013	0.013	0.007	0.008
Laos	138	9	13	11	9	0.002	0.002	0.002	0.002
ASEAN		**66,102**	**89,743**	**70,845**	**50,421**	**15.459**	**15**	**13.474**	**13**

"We think that the demand of services in retail banking and SMEs sector in ASEAN markets are unfulfilled and E.SUN should capture in this segment in region soon" Ms Kathy Kuo said. As PricewaterhouseCoopers forecast, Vietnam, Indonesia banking sector will maintain the high growth during 2010-2050 period. The proportion of Vietnam banking sector's asset in world will increase from 0.2% to 1.4% with average rate 9.3% while Indonesia's will rise from 0.3% to 1.6 with average rate 8.4%. (Fig.10) This forecast has demonstrated for potential growth of ASEAN banking sector in long term.
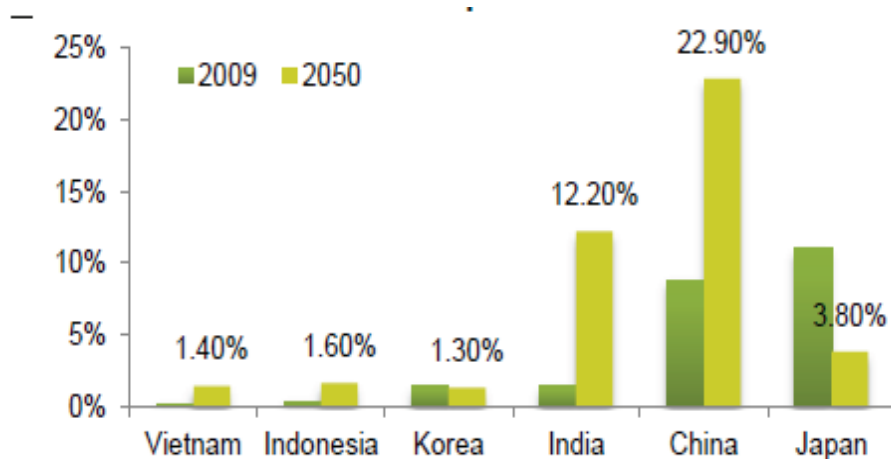
Fig.10. Banking sector's asset proportion forecast up to 2050

As stated in literature review, one of important reasons to expand overseas is follow customers. For E.SUN Bank, they need to follow its Taiwanese customers who have done business in foreign markets. China, ASEAN countries such as Indonesia, Vietnam, Cambodia are locations of many Taiwanese big firms like: Formosa, Hon Hai, Foxcon, Quanta....etc. These firms highly need in loans, trade finance service, foreign exchange transaction to run business smoothly in overseas. Thus, many Taiwanese banks such as Cathy Bank, Fubon Bank, Sino Pac… has established its branches or subsidiaries in these markets to serve Taiwanese firms. As usual, Taiwanese companies prefer to do transactions with Taiwanese banks thank to the same language, culture and it's a biggest advantage for Taiwanese banks to have customers' loyalty in overseas markets.

There is no exception for E.SUN Bank to go abroad because follow customers to meet their demand at overseas market is the key factor to keep them maintain relationship with E.SUN Bank. Ms Christine Lai mentioned "Many our clients has expanded business in Vietnam, Indonesia and Philippines.., so that we have to establish foreign branches over there to serve them". Otherwise, E.SUN can take the risk of lost customer because of the lack of service in overseas in long time. Thus, E.SUN Bank with its reputation of high quality service therefore has to take much efforts to go abroad to serve its customers as the priority reason.

Explore Resources and Capabilities

"The huge growing intra-regional trade flow in Taiwan -China-ASEAN is the key factor affecting E.SUN's international strategy" Ms Kathy Kuo said. Thus, like one of common trend in global markets, regionalization, by focusing on a particular region, E.SUN can better understand the cultures, legal and social norms, and other factors that are important for effective competition in ASEAN markets. In additional, Mr.James Chen argued "E.SUN Bank may be take advantage of regionalization because some ASEAN markets are more similar and some coordination and sharing sources would be possible". Therefore, E.SUN's expansion strategy obviously is building a hub in ASEAN region providing diversified financial services for customers and it will be important base for E.SUN enter in other markets in Asia.

Mode of entry

Since E.SUN Bank has taken much effort to have its presence in majority of countries in ASEAN to set up network, it needs seriously consider to the mode of entry to minimize risk and cost of expansion. Thus, E.SUN Bank enters in to ASEAN markets though establishing Representative Office and Branch which are considered as its wholly owned subsidiary."E.SUN Bank is operating one Representative Office in Hochiminh City, Vietnam and one branch in Singapore in 2012. We plan to expand to Myanmar, Thailand and Cambodia in next 3 years" Ms Kathy Kuo said.

Risk management

Risk management is an important issue need to be controlled effectively. Thus, centralized system is applied for foreign branches to mitigate operation risks due to the monitory of headquarter. In particularly, "the majority of big deals for credit line are decided by E.SUN Headquarter. Foreign branches are responsible to contact with clients, check their legal information and summit to Headquarter with their own suggestions" Mr. Dennis Chung mentioned.

Strategic Competiveness Outcome

From the regionalization in ASEAN, E.SUN Bank is able to get better performance and business results thank to the strategic competiveness outcomes (see Fig.11).
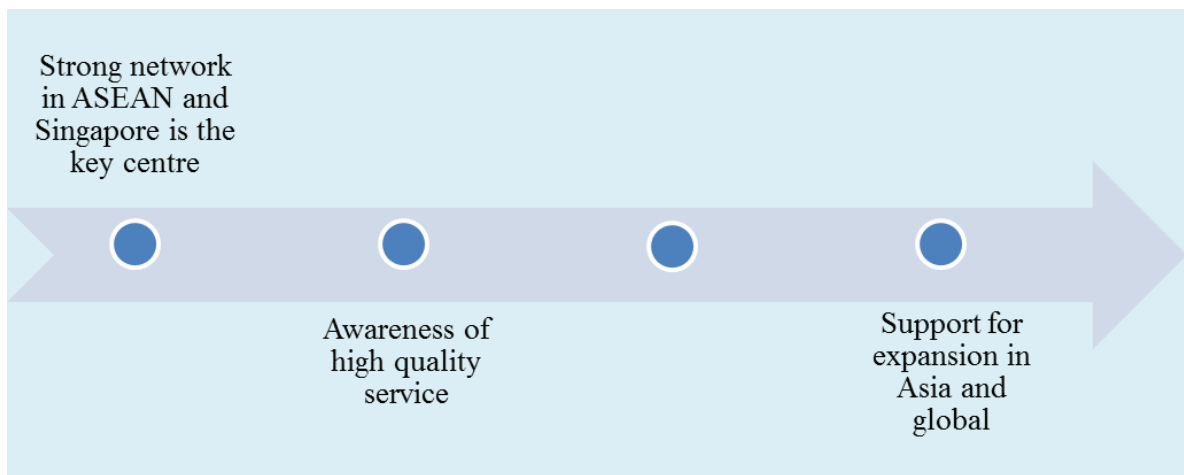
Fig.11. Strategic Competiveness Outcomes (2012 -2030)

CONCLUSION AND FUTURE DIRECTION

Globalization for further development is the common trend in Taiwan banking industry since the over banked situation and the overseas expanding of many Taiwanese firms. Regionalization is a reasonable international strategy for E.SUN in ASEAN markets due to its limited in capital, size and ranking in banking industry. In particularly, the regional strategy of E.SUN Bank is the combination of three main factors: Customer, Geography and Capability. In which Singapore is the centre hub and is responsible to support and share resoures in region. Taking advantages of Taiwanese firms and the unfulfilled demand in retail banking and SMEs sector in ASEAN, E.SUN Bank is going to capture market by strengthening its service quality. Thus customer satisfaction not only is its target but also is demonstration for the sucess of regional strategy in ASEAN.

This research only analyzes the overall of ASEAN markets and does not specified information in particular country as well as does not mention some countries like Myanmar, Laos, and Brunei. Because the expansion of E.SUN Bank in ASEAN is quite new with one branch in Singapore (2012) and one Representative Office in Vietnam (2005), there is not enough information for financial and specified products estimation in region. For further research, it can be the study of E.SUN Bank in particular market with detail fields such as: Centralized – Decentralized in Risk management; Strategy for Small Medium Enterprises; Resource and Policy for efficient cross-selling; Appropriate mode of entry: Merger and Acquisition, Joint Venture or Branch.

REFERENCES

CORPORATE GOVERNANCE AND CORPORATE PERFORMANCE - THE CASES OF MERGERS

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ABSTRACT

Purpose: Because the companies developed rapidly, they faced growing problems. In order to achieve the effective sustainable operation, the corporate governance has become an important issue. The existence of corporate governance is to reduce or avoid the agency costs, which aims to make the investors and stakeholders of firms have oversight of the pipeline company's internal managers, and thus obtain a reasonable and fair treatment. Mergers and acquisitions are expected to generate operating synergies and to enhance the company's operating efficiency, and thus to increase the value of the company. The purpose of our study aims to understand the relationship between corporate governance and corporate performance of merger companies.

Design/methodology/approach: The study investigated the merger cases from listed companies of Taiwan stock exchange from January 1, 2007 to December 31, 2012. The sample is taken from the history information of Market Observation Post System (MOPS). The sample was filtered and screened individually based on the keywords of "conducting merger, merger, consolidation holdings, merger date", the total sample of 217 firms. After excluding incomplete information disclosure of 69 firms, there is sample of 149 firms. In addition, financial information of the sample is from the "Taiwan Economic Journal (TEJ)". The internal corporate governance variables are the size of the board of directors, the size of independent directors, the setup of supervisor and audit committee, the duality of CEO and chairman of the board, the compensations of managers, the compensations of directors, the insider ownership, the corporate ownership, and the government ownership. Dependent

variables are return on assets and price to book ratio. And control variables are the firm size and research and development expense ratio.

Findings/conclusions: *According to the empirical results of least squares regression, there are three important findings. First, return on assets are positively related with the size of independent directors, the compensation of directors, the insider ownership, the government ownership. Second, price-book ratio are positively related with the size of independent directors , the setup of supervisor and audit committee, the duality of CEO and chairman of the board, the compensation of directors, the insider ownership, the proportion of domestic institutional ownership, the government ownership, the R & D expense ratio. Finally, the return on assets and price-book ratio are significant positively related with the size of independent directors, the compensation of directors, and the government ownership.*

APPLYING REAL OPTIONS THEORY TO THE RIGHT OF RAILWAY TICKET RESERVATION

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ABSTRACT

Due to the easy access of online railway ticket booking system and free charge of ticket cancellation, the average cancellation rate of Taiwan traditional railway is higher than fifty percent. The situation of holding reservation tickets and ending up with cancellations really harms the customers' rights to make reservations afterwards and also the revenues of the operator.

To reduce the impacts of this holdback situation, this research regards holdbacks as a cost item when calculating customer lifetime values. When a customer incurs high holdback cost that makes his customer lifetime value below 0 or certain amount, the abandon right in the real options theory can be exercised. We utilize a real internet reservation dataset from a railway company and calculate customer lifetime value for each reservist. The reservation process is simulated and incorporated with the above calculation to decide whether the company should exercise its right to issue a seat reservation to a customer or reject it for each reservation application.

Our study compares the results under different scenarios, including first-come-first-served, traditional customer lifetime value calculation and real options-based lifetime value calculation. The results show that the real option-based scenario can improve the success rate of reservation for high-value customers, reduce the overall cancellation rate, and raise the total revenue.

Keywords: reservation, cancellation, simulation, holdback, customer lifetime value,
real options

INTRODUCTION

Taiwan Railways Administration (TRA) is the largest railway service provider in Taiwan. With the popularity of Internet usage, the TRA launched an online railway ticket booking system to make consumers more convenient to book. However, due to the easy access of online booking

system and free charge of ticket cancellation, the average cancellation rate of Taiwan traditional railway is higher than fifty percent. The situation of holding reservation tickets for a period of time and ending up with cancellations really harms posterior customers' rights to make reservations.

In the past, it seemed that sellers didn't think about some customers might bring negative impacts to them. Until recent decade, academic studies started to explore customer lifetime values by using customers' historical purchasing data to calculate their expected future revenues. However, in most of the studies, sellers always passively accept every customer's consumption with no condition. In this study, because the TRA is confronting the challenge of ticket holdbacks- temporarily holding ticket reservations but cancelling them eventually, we suggest to consider this negative impact into the evaluation of customer value and apply the give-up right from the real options theory to decide whether to issue a ticket reservation right to a customer.

In this research, we will provide some implementation strategies and use computer simulation models to compare their performances. We hope to evaluate the applicability of picking out unprofitable customers via the combination of real options, customer lifetime value theory and dynamic simulation techniques and provide insights for practice.

LITERATURE REVIEW

Sherden (1994) proposed the 80/20/30 rule, which stated that the top 20% of the company's customers could create 80% of the company's profits, but serving the bottom 30% unprofitable customers would result in the loss of most of the company's profits. If a company could not correctly identify who the company's "true friends" and "strangers" are , it might lose its profit. Tarokh & Sekhavat (2006) also pointed out that entrepreneurs always serve unprofitable customers too much that they actually are not worth of being treated like that. So if we can tell who unprofitable customers are and give up investing them, the unnecessary expenditures will be lower and the resources would be allocated more appropriately. In order to distinguish customer's profitability, calculating customer's lifetime value becomes one of most important manners for companies.

A customer' value could utilize their previous purchase history information to evaluate how much profits they will contribute. Further, Kumar, Ramani, & Bohling (2004) argued that we had to predict customer's future behavior to have a better estimate of a customer's contribution. Hence, they introduced customer lifetime value (CLV) as a better tool than the traditional past-purchase comparison method. Collings & Baxter (2005) considered CLV complement the shortcomings of traditional instruments on financial variables. Many scholars suggested that the concept of CLV helped companies to segment the market and allocate resources. For example, Dwyer (1997) considered the customer lifetime value is the sum of cumulated cash flows — the

expected return of the customer minus the cost they have brought (e.g., direct costs of customer service and communication costs). This definition gives us the idea of taking passenger's negative behavior as a cost and incorporating it into the calculation of CLV.

However, evaluating customer values by traditional discounted cash flow approach can't be adapted to the uncertain of market and the competition among companies in reality. In real life, entrepreneurs face a series of choices in their future stages and thus they have to consider investing resources stage by stage instead of deciding once at its beginning. Because resources are reversible, if we simply utilize net present value to invest in one time, it might produce a great of loss. So the concept of financial options was proposed to help decide whether delaying decisions, expanding, reducing or giving up investing in various stages of future life. This is the concept of real options (Haenlein, Kaplan and Schoder, 2006). With this theory, we can assess the performance of each customers' profitability and measure whether to allocate seat resource to them with time.

In order to reduce the appearance of false demand and operating losses effectively, this study will provide a rigorous scenario based on the real options theory. Whenever a customer arrive to reserve a seat or seats, he will be check whether his value is higher than a given threshold or not. But as a public organization, if every low-value customer encounters rejection in the beginning of ticket reservation, there must have some complaints among these lower-value customers in practice. So this study will propose another slack scenario: The unprofitable customers could reserve tickets at their first trials, but, as long as the customer makes a cancellation, the TRA will to issue the give-up right to stop investing immediately and make the ticket be reservable for other customers. Finally, we will use computer simulation models to compare their results and then make recommendations for the above two scenarios.

METHOD

Design
The study uses the TRA's telephone and online reservation database for the West Route travelers during the period of August through October in 2010. There were 1,424,796 transactions records and 332,584 domestic passengers in the dataset.

Procedure
The passengers in the dataset were classified into three groups via a recency, frequency and monetary (RFM) technique in Huang (2013). The classification was based on customers' scores on recency, frequency, average monetary, total miles travelled, average status score and purchase probability. These three groups were named as high-worth, median-worth and low-worth groups.

Next, the reservation situation of each group for each train during the periods from August to October, 2010 was aggregated by status to build a tree probability to estimate each customer's possible future actions utilizing the method from Murphy (2004). An example of the tree probability is shown in Figure 3-1.

As long as a customer arrives at the booking system, the system can immediate response to predict the probability of his posible behaviors. For example, if a customer makes a reservation in the first period, the probability that he would continue to buy tickets in the future (in period 2) is 1.87% (that is, 2 divided by 107).

Period 0	Period1			Period 2		
	Purchase	107 persons	$94,124	Purchase	2 persons	$1,828
				Cancel	3 persons	$0
				Overdue	1 persons	$0
				No purchase	101 persons	$0
low- worth	Cancel	701 persons	$0	Purchase	31 persons	$24,106
				Cancel	50 persons	$0
				Overdue	9 persons	$0
				No purchase	611 persons	$0
	Overdue	336 persons	$0	Purchase	0 persons	$0
				Cancel	7 persons	$0
				Overdue	10 persons	$0
				No purchase	319 persons	$0

Figure 3-1 Expected probabilities of follow-up actions and expected purchase amount of customers for low-worth customers

Through the tree probability diagram, we can estimate each customer's CLV by using his conditional probability of all actions in five periods to multiply with his average ticket purchase amount and his average times of ticket cancellation and overdueness, respectively.

In order to reduce the occurrence of the holdback, this research set thresholds for the expected CLVs to select prospective customers. One base scenario and two scenarios were proposed to compare how considering customer's value to issue ticket reservation could make a difference. The basics of the scenarios are described as follows.

Scenario 0: this is the base scenario that customers get their reservations by the orders they arrive at the booking system.

Scenario 1: this scenario compares each customer's CLV with a pre-determined threshold when they arrive. Each arriving period has its own threshold which aim is screening out the lowest 10 % customers from reserving tickets.

Scenario 2: this scenario abandons customers when their CLV is equal or less than 0. This strategy applies the concept of real options.

Analysis

In order to explore the effectiveness of two scenarios, this study will simulate an actual ticket booking system process, and we will select Western popular line which has representation in TRA, and runs the major railway stations in Taiwan. There are 586 seats in total. The processes of the simulation model are as follows:

1. A customer arrives at the booking system at a given time according to the inter-arrival distribution calibrated from the group he belongs to. There are three customer groups, including high-worth, median-worth, and low-worth groups, as described in the previous section.

2. The customer's booking behavior is given from a random drawing from the database of the customer's group. Hence, for example, the attributes about the percentages of ticket purchase, cancellation and overdue, the distribution of his travel sections, the average number of tickets booked, and the average amount of spending for each reservation are attached to the customer to simulate his behavior in the model.

3. When the customer's travel section is chosen, the booking system will check whether the number of tickets in the selected section is available. If there are enough tickets and the customers' value are above the specified threshold, then he will get the reservation. In scenario 1, we specify a different threshold in each period, while in scenario 2, there is only one threshold for all periods to decide whether he is profitable. If there are no tickets or the customer is less than the filtering value, he would not get any tickets.

4. After the customer's tickets are booked, the remaining number of tickets in the travel section will be deducted. Then the subsequent actions (purchase, cancellation and overdueness) of the customer will be based on the probabilities of his historical experience. For example, if the customer's probabilities of getting tickets, cancelling booking and being overdue are 40%, 40% and 20%, respectively, he will have a follow-up behavior according to these probabilities.

5. If the customer cancels his booking, the tickets will be returned back to the corresponding travel section the next day for other travelers to book.

6. If the customer is overdue, the tickets will be returned back to the corresponding travel section after the second day of the reservation.

7. If the booking attempt fails, the customer may come back the next day to rebook his tickets according to his rebooking probability. The maximum rebooking time is set to three in this study.
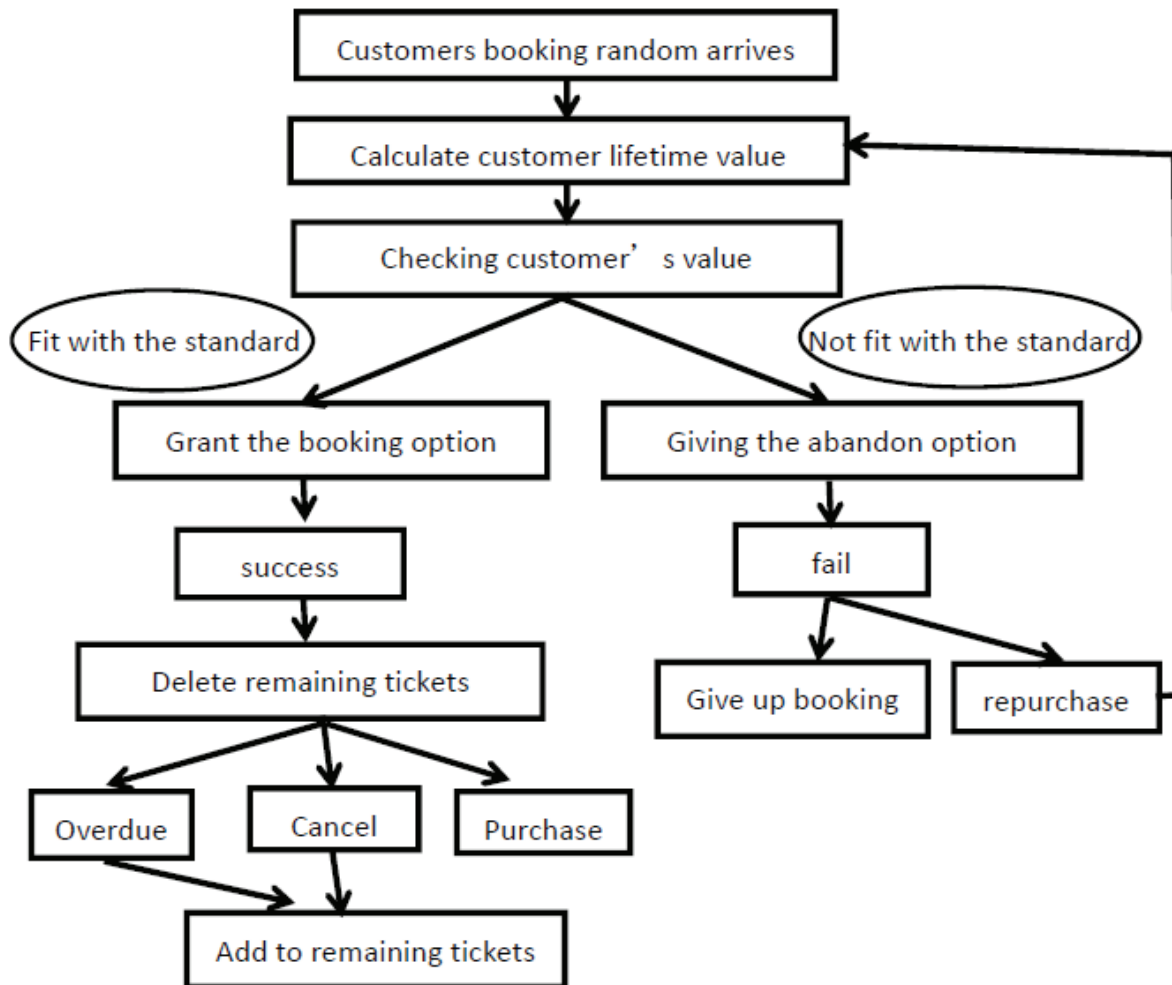
Figure 3-2 The process of the simulation models

RESULTS

Each scenario has ten replications and gets the following results in Table 4-1, Table 4-2 and Figure 4-1.

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Technology Innovation and Industrial Management
28th-30th May 2014, Seoul, South Korea**

Table 4-1 The results of each scenario after successfully booking

	Scenario 0	Scenario 1	Scenario 2
Average number of tickets sold	228.2	223.2	232.1
Average rate of purchased tickets	11.12%	11.08%	11.5%
Average number of canceled bookings	280.8	270.8	254.7
Average rate of canceled bookings	13.68%	13.45%	12.62%
Average overdue number of tickets	115.6	111.9	82.1
Average rate of overdue tickets	5.63%	5.56%	4.07%

The simulation results show that there are no differences between the two booking scenarios and the original scenario. But according to the average numbers of tickets sold, it still can be found the reducing of holdbacks, which means that the scenario one and two can make the incidence of the holdbacks lower.
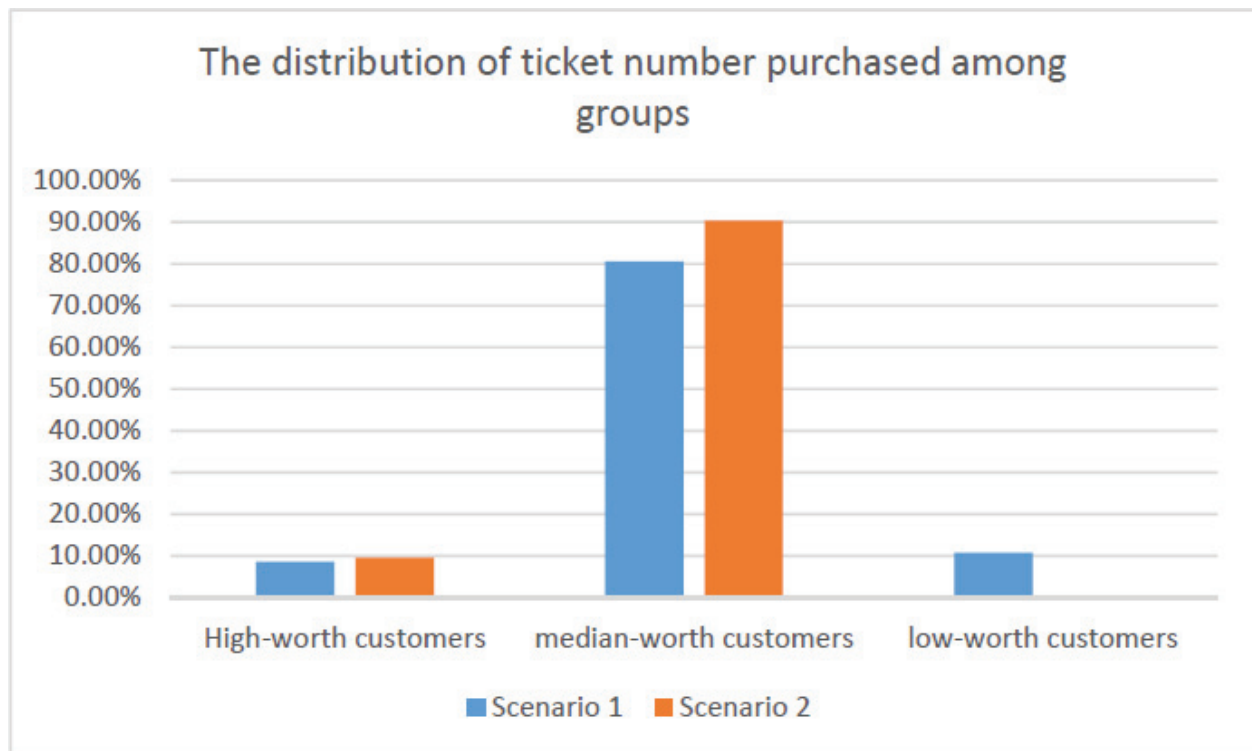
Figure 4-1 The distribution of ticket number purchased among groups

In addition, Scenario 2 successfully screens out low-worth customers, and this enables high-worth and median-worth customers getting more tickets.

Table 4-2 The contributions of each scenarios

	Scenario 0	Scenario 1	Scenario 2
Expected number of purchased tickets	228	223	232
Expected cancellation	397	383	337
Total expected revenue	970518	999352	1051638
Total expected loss	5161	4979	4381
Expected net profit	965357	994373	1047257

Finally, from the overall operation profits in Table 4-2, Scenario 2 can sell more tickets and get higher revenue than the others. The expected loss from cancellations and overduenesses in Scenario 2 is also much lower than the other two scenarios. So the Scenario 2 is a better strategy to improve the situation of tickets holdbacks and produce more profitable booking outcomes.

CONCLUSION

In this study, we use the historical data from the TRA online transaction database to analyze customers' CLVs and use these values to implement a real options-based reservation strategy. We then use the computer simulation techniques to investigate the online railway ticket booking by incorporating the customer evaluation thresholds calculated via the CLV theory and the real options theory respectively. From the comparison results, they show that the real option-based scenario can improve the success rate of reservation for high-value customers, reduce the overall cancellation rate, and raise the total revenue. In addition, from considering the holdback costs into the calculation of customer values, a company can both improve its revenue and increase customers' satisfaction at the same time.

REFERENCES

1. Blattberg, R. C., & Deighton, J. (1996). Manage Marketing by the Customer Equity Test. *Harvard Business Review* 74(4), 136-44.
2. Dwyer, F. Robert. 1997. Customer Lifetime Valuation to Support Marketing Decision Making. *Journal of Direct Marketing* 11(4), 6-13.

3.   Haenlein, M., Kaplan, A. M. and Schoder, D. (2006) Valuing the Real Options of Abandoning Unprofitable Customers When Calculating Customer Lifetime Value. *Journal of Marketing,* 70(3), 5–20.

4.   Huang, R. H. (2013), On Responsive Railway Pre-sale Strategies, Master Thesis, National Chung Hsing University.

5.   Kumar, V. (2008), Customer Lifetime Value: The Path to Profitability, *The Netherlands: NOW Publishers Inc.*

6.   Kumar, V., Ramani, G. and Bohling, T. (2004), Customer Lifetime Value Approaches and Best Practice Applications, *Journal of Interactive Marketing* 18 (3), 60-72.

7.   Levett, P., Page, M., Nel, D., Pitt, L., Berthon, P. and Money, A. (2011). Towards an Application of Option Pricing Theory in the Valuation of Customer Relationships. *Journal of Strategic Marketing* 7(4): 275-284

8.   Tarokh, M. J. and Sekhavat, A. A. (2006). LTV Model in Consultant Sector. Case Study: Mental Health Clinic. *Behaviour & Information Technology* 25(5): 399-405.

9.   Willian, A. S. (1994). The Art & Science of Becoming #1. New York: Amacom Press.

MEASURING COST EFFICIENCY - APPLICATION ON PRODUCTION OF CAPACITORS

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ABSTRACT

This is our third article presented within international conferences which addresses issues about cost efficiency measurement techniques and methods (Novak and Žižmond, 2011, 2013). Our basic aim is to present another application of our original Overall cost efficiency (OCE) framework (Novak and Žižmond, 2012).

Our special research focus is automated production line for mass production. In such cases the use of a key performance indicator (KPI) termed as Overall Equipment Efficiency (OEE) is very popular. The OEE is a productivity metric that estimates the technical efficiency of a production process by controlling the availability rate (A), performance rate (P) and quality rate (Q) of the production process: $OEE = A \cdot P \cdot Q$.

There exists extensive reference literature on the explanation and prediction power of OEE and its practicability for productivity management. However, OEE methodology approaches production optimization only from the technology point of view and ignore the economic perspective of the optimization. To overcome this obstacle, we offer Overall cost efficiency (OCE) methodology.

The present paper shortly describes OCE as new key performance indicator (KPI), which measures not only the technical efficiency of production, but also the belonging cost efficiency in real time. Everything that has an influence on production has also a systematic impact on production costs. 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.

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 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:

(1) Decreasing availability (A) raises average fixed costs, while average variable costs remain unchanged.
(2) Decreasing performance (P) raises average fixed costs, while average variable costs remain unchanged.
(3) Decreasing quality (Q) raises average fixed costs as well as average variable costs.
By introducing costs (AC = average costs, AFC = average fixed costs and AVC = average variable costs) and by reducing the equation we obtained the final OCE algorithm:

$$OCE = \beta1 / OEE + \beta2 / Q$$

β1 and β2 being cost parameters measuring the impact of fixed and variable costs, respectively, on the cost efficiency.

This equation is the final solution to our research problem. As we can see, there is an inverse relationship between OCE and OEE, where the quality rate (Q) has an additional impact via variable costs.

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 could 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: A = 1, P = 1, Q = 0.8 → OEE = 0.8; OCE = 1.25
Example 2: A = 0.8, P = 1, Q = 1 → OEE = 0.8: OCE = 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 would be 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 would be 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 favor 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.

The pilot case study was made in a Slovenian company which produces capacitors. It is our aim to present this case study at the conference.

Keywords: Overall equipment efficiency (OEE), Overall cost efficiency (OCE), Industrial Management

REFERENCES

NOVAK, Matjaž, ŽIŽMOND, Egon. Production optimisation : measuring technical and cost efficiency. In: SAVOLAINEN, Merja (ed.). *Proceedings of TIIM2011 conference : 28-30 June,*
2011 Oulu Finland. Oulu: TIIM, 2011, 17 p.
NOVAK, Matjaž, ŽIŽMOND, Egon. Overall cost efficiency. *Ekonomic Research*, 2012, vol. 25,
no. 4, pp. 1033-1049.
NOVAK, Matjaž, ŽIŽMOND, Egon. Overall equipment efficiency (OEE) upgraded. In: *2013 conference proceedings*. Albuquerque (NM): Decision Sciences Institute, 2013, pp. 261-269.

CORPORATE SOCIAL RESPONSIBILITY IN THE ECONOMY OF SLOVAKIA

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ABSTRACT

Purpose: The main goal of this paper is to investigate CSR in Slovak food- processing companies through analysis of their website reporting. We have analyzed the top 60 food-producing companies in Slovakia. This paper represents the adoption of CSR principles by those firms: expansion of reporting, specifics, priorities and differences of CSR perception and implementation of this concept in Slovakia.

Methodology: We have analyzed and examined the corporate websites of the top 60 companies (by operating revenue in the year 2012) for any CSR activities. Those websites where we could find activities related to CSR, were subsequently analyzed, classified and rated by our own framework. Our framework classifies the reported CSR activities according to different parameters, e.g. the type of CSR activities (economic, legal, ethical or philanthropic) their extent, their waves (socially responsible: employee relations, community involvement, products, processes, etc.) and others.

Findings: We have found out, that CSR reporting in Slovakia lags behind reporting in western countries. Similarly, CSR is mostly understood as activities connected with donation, charity and philanthropy; thus complex implementation of CSR is still missing.

Research limitations: This research is limited by the perception of CSR in Slovakia. Many firm's applying CSR, still do not report their CSR activities, despite they have a complex framework of their socially responsible behavior. Therefore, it is complicated to review all of the firms engaged into socially responsible behavior.

Practical implication: Based on our research we are going to develop guidelines and recommendations for policy and decision makers on the highest levels of organizational structures of firms, governments and non-governmental organizations and will explain, which directions should head the development of CSR in Slovakia.

Originality/value: This report is unique in the academic research of CSR in Slovakia. No research related to the same topic was conducted till now.

USER'S INTENTION FOR MOBILE FINANCIAL SERVICES

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ABSTRACT

In recent years, mobile bank continues to expand its business scope. Mobile banking is a subset of electronic banking. Users can use mobile financial services via mobile devices. This study analyzes customer intention from the mobile users view in order to get the correlation between affecting factors. Mobile Bank allows users anywhere, anytime using mobile financial services. Data are collected from 325 respondents and Structural Equation Modeling(SEM) is used to analyze the responses. Customer relationship management (CRM), service quality, and Perceived Security are the factors that influence the intention to adopt mobile banking services the most. Furthermore, the findings of this study are useful for mobile bank in increasing the use of mobile banking among its users.

Keywords: Mobile Bank; Mobile Financial Services; Theory of Planned Behavior (TPB) ; Structural Equation Modeling (SEM)

INTRODUCTION

As smartphones have become increasingly popular, mobile payment has received increased attention from service providers and users. Mobile commerce is having an increasingly profound impact on our daily lives, and beginning to offer various services. Mobile commerce will become an integral part of our lives. Shih et al. (2011) indicated that financial service industry is considered to have the contents of high tech and high knowledge. Chen et al. (2010) argued that with the development trend of mobile financial services, more and more new financial services will be provided to customers in the future. Kim et al. (2010) point out mobile payment system has emerged, enabling users to pay for goods and services

using their mobile devices wherever they go. Mobile payment is anticipated to enjoy a bright future. Yang et al. (2012) point out mobile payment is an emerging and important application of mobile commerce. The adoption and use of mobile payment services are critical for both service providers and investors to profit from such an innovation. Kemp (2013) indicated that M-payments are giving rise to the development of a new ecosystem of market participants including card schemes, MNOs, retailers, device suppliers, service providers and trusted service managers. Zhou (2013) stated as service providers need to offer quality system, information and services in order to facilitate users' continuance usage of mobile payment. Tseng(2013) point put as the mobile telecommunications market saturates in recent years, service providers need to change their marketing strategies and continuously upgrade their service quality to maintain customer satisfaction.

LITERATURE REVIEW

Service Quality

Service quality has emerged as a strategic tool to survive and thrive in the mobile commence. Parasuraman et al. (1988) proposed SERVQUAL model. Zeithamlet el al. (1990) point put SERVQUAL model has a five dimensional construct of perceived service quality tangibles, reliability, responsiveness, assurance and empathy as the instruments for measuring service quality. Attitudes will facilitate knowing how users perceive service quality in mobile commence. Czepiel(1990) point out service quality is customer perception of how does a service meets or exceeds their expectations. Balachandran(2005) indicated that users satisfaction to play a major role in the growing and diversifying mobile financial sector. Mobile banks have recognized the need to meet users aspirations.

Perceived Security

Mattila & Mattila (2005) indicated that security has been widely as one of the main barriers to the adoption of internet innovation. Pi et al.(2012) point out transaction security is the only factor that influences on affective trust of mobile users. Roca et al. (2009) suggested online financial users must improve the security of the online system since e-investors form perceptions about its perceived security. Tsiakis et al.(2012) point out consumers trust is fundamental in web transactions and is influenced by perceived security. The primary factor causing users lack on e-business is perceived security risks associated with online transactions.

Customer relationship management (CRM)

In the mobile banking industry, a key factor of users satisfaction is the relationship between the users and the mobile financial services provider of the products and services. Zeithami et al.(1996) proposed customer satisfaction is a key to long-term mobile banks success. Gerrard and Cunningham (2001) indicated that mobile banks need to understand users service requirements and how it impact on service delivery and users attitudes. Pai and Tu(2011) point out CRM systems can help organizations to gain the potential new customers,

promote the existing customers' purchase, maintain good relationship with customers as well as to enhance the customer value, thus can improve the enterprise images. High-service quality can give mobile banks an opportunity to differentiate themselves in mobile commence.

Theory of planned behavior (TPB)

The Theory of Planned Behavior(TPB), an extension of the well-known Theory of Reasoned Action(TRA), is proposed as a model to predict consumer adoption intention. TPB was proposed by Ajzen(1985), which asserts that a user's intention is affected by his or her attitude, subjective norms and perceived behavioural control (Ajzen, 1991). Attitude is defined as a person's positive or negative feeling. Attitude can be used to predict a person's intention. Intentions to perform behaviors of different kinds can be predicted with high accuracy from attitudes toward the behavior, subjective norms, and perceived behavioral control.

RESEARCH METHOD

Our research model includes five constructs, each of which was measured with multiple items. Our items were adapted from the extant literature to preserve the content validity. In this section, we shall describe the Service quality, perceived security, customer relationship management, structure development and data collection. A questionnaire was developed based on TPB for the study. We reviewed relevant literature to define each construct and integrate an initial questionnaire. After a pre-test, a few items were modified to fit the mobile banking. The items in the questionnaire were measured on the 1-5 Likert scale, anchoring 'strongly disagree' to 'strongly agree'. A total of 325 responses were collected.

REFERENCE

1. Ajzen, I. (1985). *From intentions to actions: a theory of planned behavior*. in Kuhl, J. and Beckman, J. (Eds.): Action-control: From Cognition to Behavior, Springer, Heidelberg, 11-39.
2. Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior & Human Decision Processes*, 50, 179-211.
3. Chen, L., Woods, D., Curran, K. and Doherty, J. (2010). Mobile development environments for electronic finance. *International Journal of Electronic Finance*, 4(2), 99-119.
4. Gerrard, P.,& Cunningham, B.(2001). Singapore"s undergraduates: how they choose which bank to patronize. *International Journal of Bank Marketing*, 19(3), 104-114.
5. Kemp, R. (2013). Mobile payments: Current and emerging regulatory and contracting issues.*Computer Law & Security Review*, 29(2), 175-179.

6. Kim, C., Mirusmonov, M., & Lee, I. (2010). An Empirical Examination of Factors Influencing the Intention to Use Mobile Payment. *Computers in Human Behavior*, 26(3), 310-322.

7. Mattila, A.,& Mattila, M. (2005). How perceived security appears in the commercialisation of internet banking. *International Journal of Financial Services Management*, 1(1), 89-101.

8. Parasuraman, A., Zeithaml, V.,& Berry, L., (1988). SERVQUAL – a multiple-item scale for measuring consumer perceptions of service quality. *Journal of Retailing*, 64(1), 12-40.

9. Pai, J.C.,& Tu, F.M. (2011). The acceptance and use of customer relationship management (CRM) systems: An empirical study of distribution service industry in Taiwan. *Expert Systems with Applications*, 38(1), 579-584.

10. Pi,S. M., Liao, H. L. ,& Chen, H. M.(2012). Factors That Affect Consumers' Trust and Continuous Adoption of Online Financial Services. *International Journal of Business and Management*,7(9),108-119.

11. Roca,J. C., García,J. J.,& Vega, J. J. (2009). The importance of perceived trust, security and privacy in online trading systems. *Information Management & Computer Security*, 17(2), 96-113.

12. Shih, K. H., Lin, C. W. ,& Lin, B. (2011). Assessing the Quality Gap of Intellectual Capital in Banks. *Total Quality Management & Business Excellence*, 22(3), 289-303.

13. Tseng, K. J. (2013). Assessing the indicators of reuse intention of mobile services. *International Journal of Mobile Communications*,11(3),213-224.

14. Tsiakis,T., Katsaros,P.,& Gritzalis,D.(2012). Economic assessment of externalities for interactive audio media anti–SPIT protection of internet services. *International Journal of Electronic Security and Digital Forensics,*4(2),164-177.

15. Yang, S., Lu, Y., Gupta, S., Cao, Y., & Zhang, R. (2012). Mobile Payment Services Adoption Across Time: An Empirical Study of the Effects of Behavioral Beliefs, Social Influences, and Personal Traits. *Computers in Human Behavior*, 28(1), 129-142.

16. Zeithaml, V. A., Parasuraman, A.,& Berry, L.(1990). *Delivering quality service: Balancing customer perceptions and expectations. New York*, NY: Free Press.

17. Zeithaml, V., Berry, L. and Parasuraman, A.(1996). The behavioral consequences of service quality. *Journal of Marketing*, 60, 31-46.

18. Zhou, T. (2013). An empirical examination of continuance intention of mobile payment services. *Decision Support Systems*, 54(2), 1085-1091.

THE INFLUENCE OF FINANCIAL INDICATORS ON SHARE PRICE: A CASE STUDY ON THE VIETNAMESE STOCK MARKET.

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ABSTRACT

This paper examines the data of 820 public listed companies in the Vietnamese stock market which comprises of the Ho Chi Minh stock exchange and the Ha Noi stock exchange, to determine and assess the relationship between the share price and four financial determinants: Earnings per Share (EPS), Price Earnings ratio (P/E ratio), Return on Assets (ROA), and Return on Equity (ROE). The results show that while there is a significant relationship between EPS and ROA determinants and the share price, the P/E ratio and ROE determinants seem to be independent of the share price. Furthermore, at the end of the paper, two share price determination functions will be formulated using EPS and ROA.

Key words: Share Price, EPS, ROA, P\E, ROE, Vietnam stock exchange, share price functions.

INTRODUCTION

Vietnam stock market was officially established in 2000 in Ho Chi Minh City with initially 24 companies, 140 Government bonds, two Commercial bonds, 1 Municipal bond, and VND 1.2 billion worth of capital. It is a relatively young stock market. After 13 years since its establishment there are now over 800companieslisted in the 2stockexchanges,Ho Chi Minh Stock Exchange (HOSE), and Hanoi Stock Exchange (HNX). (Yen, 2011). The development of the Vietnam stock market over the years can be generally summarized below.
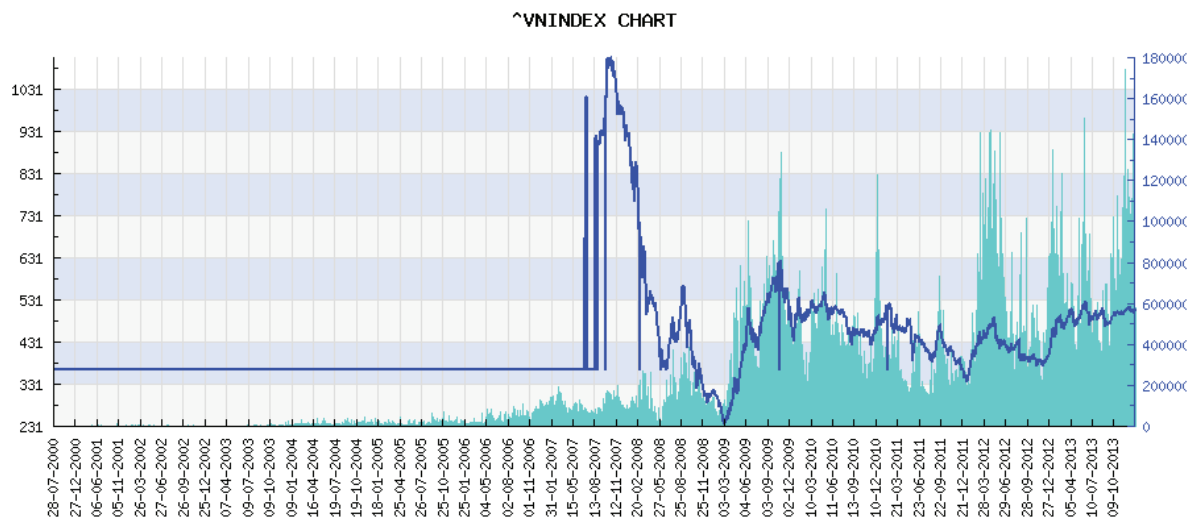
Figure1. Reproduced from: Cophieu 68

A scan be seen, the stock market index was very stable and hardly move data round 360 from 2000 to 2007. At the end of 2006, the combined market capitalization of both the HOSE and HNX is USD14 billion. Then in June 2007, VN Index experienced a phenomenal up trend that most market players lived for, and for many traders a once in a life time experience similar to that of 'Linsanity' of the United States' National Basketball Association league.

The VN Index climbed an astronomic al 200% from 360 to 1,100 within a span of 4 months. and substantial increase, and 2 months right after that it dramatically plunged to 288. The VN Index reached its nadir on March 3, 2009 at 231. That heady period of casino like trading has disappeared.

Over the next four years the Vietnam bourse has seen some semblance of normalcy with the VN Index hovering between 300 - 450.

Even though there have been a number of research on share price determinants, the number of study specifically focus on Vietnam stock market is still very limited. Therefore, this paper

has been conducted in order to provide some understanding of Vietnamese stock price' determinants.

RESEARCH PROBLEM STATEMENT

Determining share price is a very challenging job, and involves lots of uncertain ties as there are numerous factors that affect share price, for instance: the company's performance, market efficiency, macroeconomics factors like inflation, GDP, as well as investors' personal judgments.

However, for investors to maximize their wealth it is critical to accurately predict the share price to some extent. From the company's point of view it is also essential to correctly forecast the share price reactions to its dividend policy and public accounting information, because it can substantially affect the company's financial resources. In fact, a survey with the top management of 41 listed companies in Kuwait stock exchange reveals that share price is the reason that motivate70.7% of the management to pay dividends. (Al-Deehani, 2005)

As a result, this paper aims to assist investors as well as companies In the Vietnamese stock exchange in predicting the share price by determining the relationship between share price and some selected financial indicators, and finally formulate a couple of functions for stock price prediction.

LITERATURE REVIEW

In the field of study of capital market reaction to financial reports, Ball and Brown (1968) are known as the pioneers; their study is to assess the usefulness, and timeliness of annual financial reports for investors. The study's result shows that even though information provided in the annual report is relevant to the decision making process of investors, the majority of the information (85% - 90%) had already been known prior to the announcement of the annual reports through other sources.

One branch under the capital market research is to identify the financial variables that influence the share price, and evaluate the impact they have on share prices. In 1995, Ohlson developed a firm market value determination model using earnings, book value, and dividend. This model later has become the foundation for the study of various accounting researchers such as Kadri et al. (2009), and Malik et al. (2012). Even though various studies have been conducted, the result varies considerably from different countries, stock markets, sectors, and reporting regimes.

For example, a recent research conducted by Haque et al.(2013) using Reneta Pharmaceuticals Limited, a Bangladesh company as a case study for the period between 2004 and 2011 identified a substantial impact that EPS has over share price. To illustrate, it was

revealed that there was a very strong correlation of 70% between share price and EPS. Additionally, the study also evaluates the relationship between share price and 6 other factors: Cash Flow per Share (CFPS), (Dividend Payout Ratio) DPR, Price Earnings Ratio (P/E), Return on Assets (ROA), Return on Equity (ROE), and Cash Dividend per Share (CDPS), and the coefficient of determination was 60%, 57%, 51%, 46%, 33%, and 33% respectively.

1.1 ROA and share price

1.2 P/E ratio and share price

1.3 DPR and share price

1.4 EPS and share price

1.5 BVPS and share price

1.6 CDPS and share price

1.7 ROE and share price

1.8 CFPS and share price
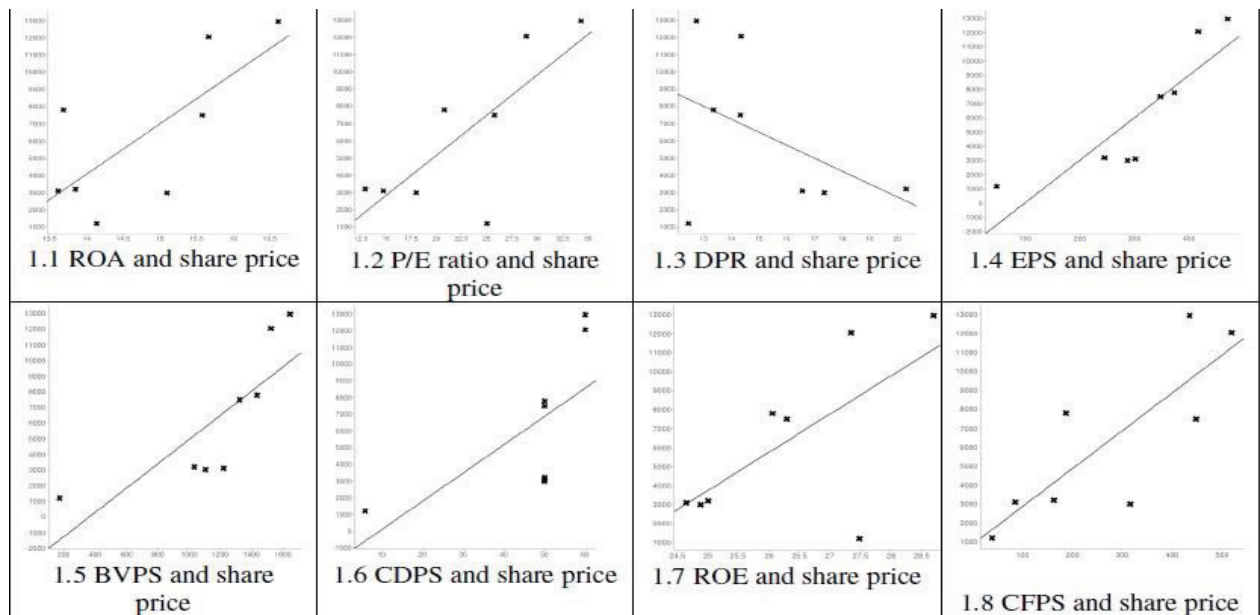
Figure2. Reproduced from: Haque et al. 2013

Menaje (2011)'s study on the share price of public companies in Philippine reconfirmed the significant relationship between share price and EPS at 85.2%. However, the result for ROA is contradictory to Haque et al. with a negative correlation of -26.3%.

Srinivasan (2012) employed Fixed Effects model, and Random Effects model to analyze 6-year data (2006-2011) of Indian companies from various sectors to gain an in-depth understanding of the stock price's determinants. The research result is summarized as below:

Table 1 developed for research

	Dividend per Share		Earnings per Share		Price Earnings Ratio		Book Value	
	Fixed Effect	Variable Effect	Fixed Effect	Variable Effect	Fixed Effect	Variable Effect	Fixed Effect	Variable Effect
Heavy Manufacturing	-0.0326	-0.0140	0.9624	0.9981	0.9458	0.9855	0.0482	-0.0001
Pharmacy	-0.0489	-0.1761	0.3763	0.5776	0.3539	0.5363	0.5564	0.2792
Energy	-0.1866	-0.2249	0.1705	0.1667	0.2263	0.2454	0.4688	0.4555
IT	-0.0920	-0.3289	0.0659	0.0971	0.0647	0.1419	0.5513	0.4104
Infrastructure	-0.1706	-0.1592	0.5454	0.6335	0.6655	0.7677	0.2465	0.0755
Banking	0.0538	0.0228	0.8655	0.9684	0.8925	0.9882	0.1324	-0.0723

The study's result demonstrates that the relationship between dividend and share price is often negative except for the banking sector; however regardless of the sectors the relationship between these two variables is often too weak, consequently they can be considered as independent. Furthermore, EPS, and P/E is positively related to share price. Never the less the strength of the relationship varies greatly across sectors from very significant to nearly non-existence. For Book Value there is also a positive relationship, but the strength of the relationship only ranges from insignificant to moderate across sectors.

Another research identifying the stock price's determinants was carried out by professors Uddin, and Rahman from Khulna University (2013); however this study only focused on Bangladeshi finance firms. Data from 2005 to 2011 of over 70 financial firms in the Dhaka Stock Exchange was collected; however the result over the years were very in conclusive. For instance, from 2005 to 2008 over 70% of variations in share price can be explained by financial variables such as EPS, Net Asset Value (NAV), Net Profit after Tax (NPAT), and P/E; whereas in 2010 this figure is only 67.3%, and in 2009 these financial indicators can explain less than 30% of differences in the share price.

Table 2 summary table from 2005 to 2011 of over 70 financial firms in the Dhaka Stock Exchange

Year	EPS	NAV	NPAT	P/E	Total
2005	0.805	0.817	0.31	0.009	0.902
2006	0.719	0.631	0.20	0.047	0.901
2007	0.061	0.278	0.001	0.163	0.763
2008	0.517	0.419	0.023	0.22	0.745
2009	0.137	0.258	0.009	0.001	0.29
2010	0.652	0.649	0.039	0.008	0.673

In2012, in order to measure the effects of EPS, and Book Value per Share on stock price data of 52 listed companies from non-financial sectors in Karachi Stock Exchange was collected and analyzed (Maliketal.,2012). The study shows that EPS is once a gain the most vital determinant of stock price with a very high correlation of 66%. The impact of the share's book value on share price is however not very significant, as the degree of correlation between the two variables is only 47%. The study also assessed the combined effect that EPS and share's book value have on share price, which is 64%.

However, the share price's determinants, and their impact are not only different from sector to sector, but also different under different accounting reporting standards. Kadri et al. (2009)'s research is an excellent demonstration for that. To demonstrate, under the period from 2002 to 2005, when the Malaysian Accounting Board's Standards (MABS) is applied, the correlation level between Book Value and Earnings, and share price is respectively 0.720 and 0.565. On the other hand, in the 1st and 2nd year when the new Financial Reporting Standards (FRS) was introduced to Malaysia, the 2006 and 2007 figures increased by nearly 14% for Earnings and just over 12% for Book Value.

Table 3 summary comparison table of MABS and FRS

	Book Value	Earning
MABS	0.720	0.565
FRS	0.809	0.644

The above discussion leads to the following research model.
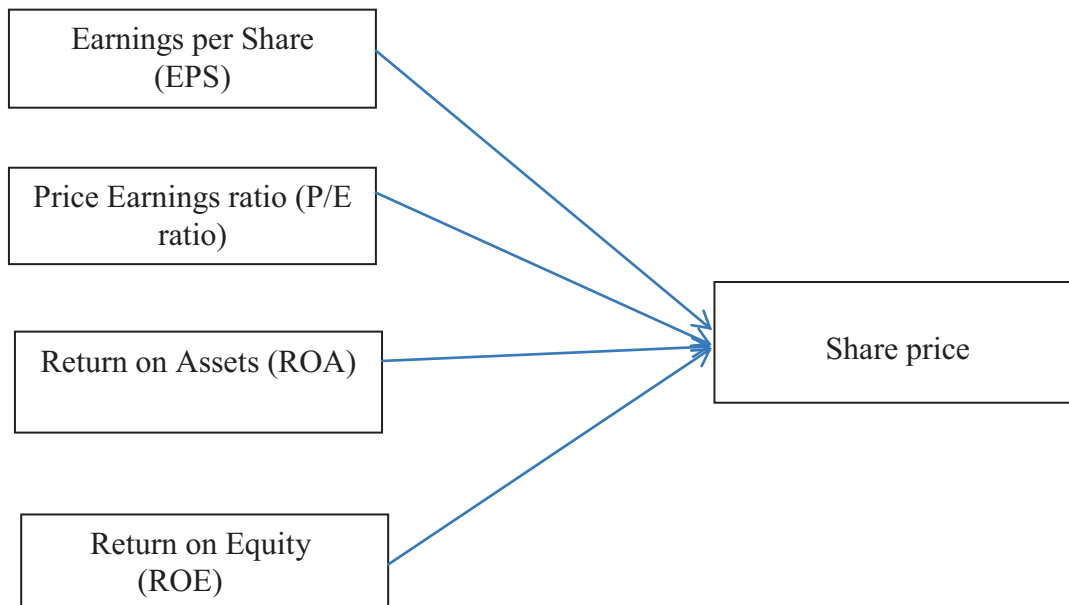
Figure 3. Proposed research model

METHODOLOGY

The research was conducted by firstly collecting critical financial indicators such as EPS, ROA, P/E ratio, and ROE as well as the share price of 820 publicly listed companies in Vietnamese stock exchanges from Viet Capital Securities' website.
After that regression analysis is undertaken to determine to what degree changes in share price are linked to changes in EPS, ROA, P/E ratio, and ROE.

Finally, based on the regression analysis, functions to predict the stock price using the above mentioned ratios are developed.

FINDINGS

Earnings Per Share & Return On Assets
EPS which is the amount of a company's profit al located to its outstanding common stock is often
Known as the most fundamental or essential factor in determining the stock price. EPS is calculated as:

$$Earnings\ per\ Share = \frac{Net\ Income}{Total\ Numbers\ of\ Outstanding\ Shares}$$

ROA, which evaluates a company's net income as a percentage of its assets, is also often considered as a determinant to share price. ROA is calculated as:

$$ROA = \frac{Net\ Income}{Total\ Assets}$$

Table 4. Regression Analysis between Share Price and EPS

Regression Statistics	
Multiple R	0.709970715
R Square	0.504058416
Adjusted R Square	0.50345213
Standard Error	11029.17314
Observations	820

	df	SS	MS	F	Significance F
Regression	1	1.01132E+11	1.01132E+11	831.3878026	1.0587E-126
Residual	818	99503695939	121642660.1		
Total	819	2.00636E+11			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	5652.77 9234	482.645 8025	11.7120 6546	2.1202 2E-29	4705.40 9091	6600.14 9377	4705.40 9091	6600.14 9377
EPS	4.74979 5789	0.16473 0158	28.8337 9619	1.0587 E-126	4.42645 2186	5.07313 9393	4.42645 2186	5.07313 9393

Table 5. Regression Analysis between Share Price and ROA

Regression Statistics	
Multiple R	0.616926455
R Square	0.380598251
Adjusted R Square	0.379841036
Standard Error	12325.76563
Observations	820

	df	SS	MS	F	SignificanceF
Regression	1	76361680108	76361680108	502.6291409	3.72445E-87
Residual	818	1.24274E+11	151924498.4		
Total	819	2.00636E+11			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	6595.631569	543.614576	12.13291891	2.86471E-31	5528.587753	7662.675384	5528.587753	7662.675384
ROA	1548.487307	69.06910328	22.41939207	3.72445E-87	1412.913754	1684.060859	1412.913754	1684.060859

The coefficient correlation (Multiple R) of 0.7, between share price and EPS; and 0.6 between share price and ROA demonstrates quite significant, positive relationships between these variables and share price. Coefficient correlation measures the degree to which changes in one variable associated with changes in another variable. The value of coefficient correlation can range from -1, to +1; with -1 meaning a perfect inverse relationship, +1 indicates a perfect positive relationship; 0 means these is no relationship, and the closer the value to ±1, the stronger the relationship.

R Square is the coefficient of determination which indicates the percentage of variation of a variable that can be explained by variation in another variable. Applying them to this case, for EPS the R square is 0.504058416, meaning approximately 50% of differences in share price can be

Explained by differences in the EPS; and for ROA with coefficient of determination (R Square) of 0.38, almost 40%of variations in share price can be explained by variation in the ROA.
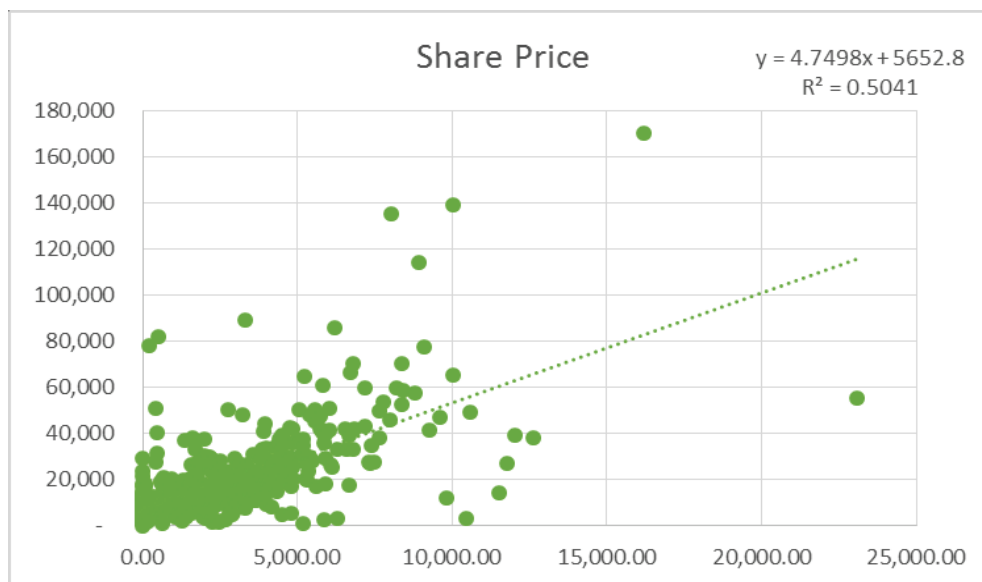
Figure 4. Scatter plot between Share Price and EPS
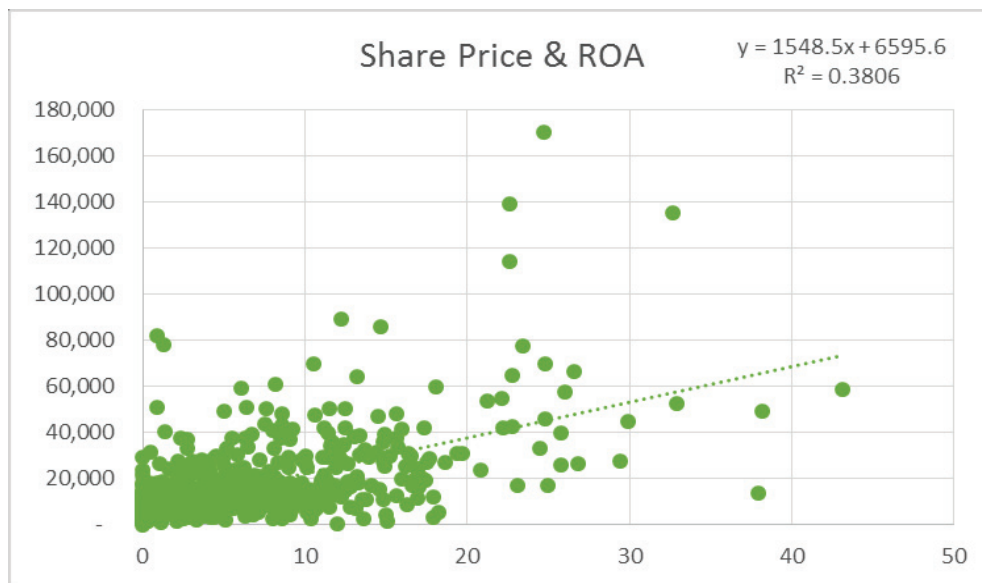
Figure 5. Scatter plot between Share Price and ROA

Both the scatter plot between share price and EPS; and the scatter plot between share price and ROA show an upward trend line which reconfirms the significant, positive relationship between these 2 variables and share price. However, in comparison with EPS the trend line between ROA and share price is not as steep. The reason is because the correlation degree between share price and EPS is stronger than between share price and ROA, 0.7 compared to 0.6

Price Earnings Ratio & Return on Equity

Other factors that are often taken into consideration when deciding whether to invest are Price Earnings ratio (P/E ratio) and Return on Equity. P/E ratio compares the share price with the earnings each share generates, it is calculated as:

$$Price\ Earning\ Ratio = \frac{Share\ Price}{Earnings\ per\ Share}$$

ROE measure the amount of profit a company generated in relation to the amount of investment its shareholders invested, it is calculated as

$$Return\ on\ Equity = \frac{Net\ Income}{Shareholders'Equity}$$

Table 6. Regression Analysis between Share Price and P/E ratio

	df	SS	MS	F	Significance F
Regression	1	40888548.18	40888548.18	0.16673809	0.683134056
Residual	818	2.00595E+11	245226199.6		
Total	819	2.00636E+11			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	14064.8 9995	550.383 4246	25.5547 3026	2.3894 E-106	12984.5 6978	15145.2 3013	12984.5 6978	15145.2 3013
P/E	-0.85427 7012	2.09209 4551	- 0.40833 5757	0.68313 4056	- 4.96078 3075	3.25222 9052	- 4.96078 3075	3.25222 9052

Table 7. Regression Analysis between Share Price and ROE

Regression Statistics	
MultipleR	0.088049213
R Square	0.007752664
Adjusted R Square	0.006539648
Standard Error	15600.46928
Observations	820

	df	SS	MS	F	Significance F
Regression	1	1555462851	1555462851	6.391228108	0.01165571
Residual	818	1.9908E+11	243374641.8		
Total	819	2.00636E+11			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	13574.4 2373	575.015 429	23.6070 5999	2.2554 2E-94	12445.7 4418	14703.1 0328	12445.7 4418	14703.1 0328
ROE	35.7254 3036	14.1314 0392	2.52808 7836	0.0116 5571	7.98734 5648	63.4635 1507	7.98734 5648	63.4635 1507

Coefficient Correlation (Multiple R) between share price and P/E ratio, as well as ROE is very small, and almost zero suggests that the re is no relationship existed between these two variables and share price

Furthermore, coefficient to f determination (R Square) of respectively 0.0002,and0.0077means that P/E ratio, and ROE can only explain0.002%,and0.77%variationinshare price, which can be considered as too insignificant and can be ignored.

In addition, the scatter plots between the share price and these two variables also graphically demonstrate that there is no correlation between them.
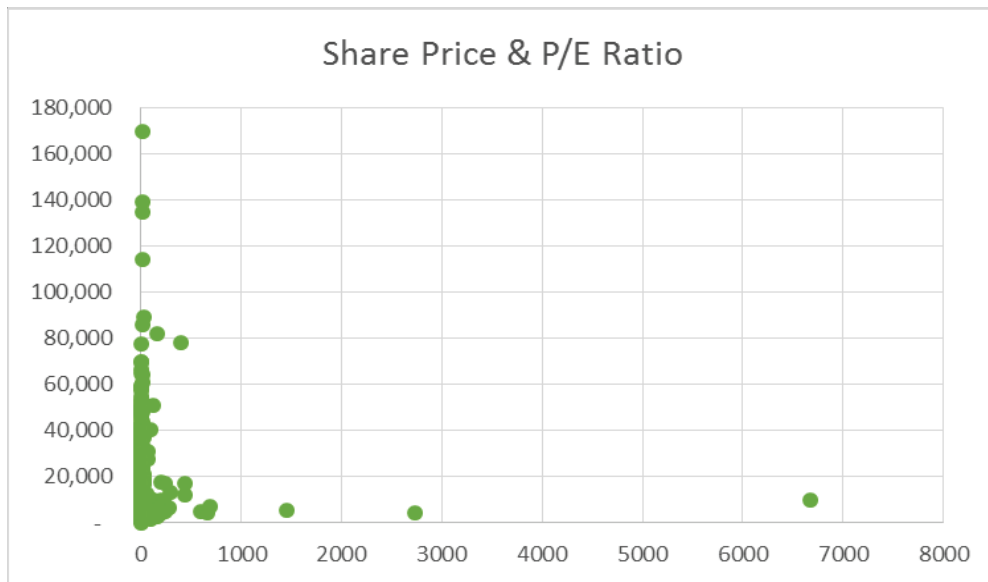
Figure 6. Scatter plot between Share Price and P/E ratio
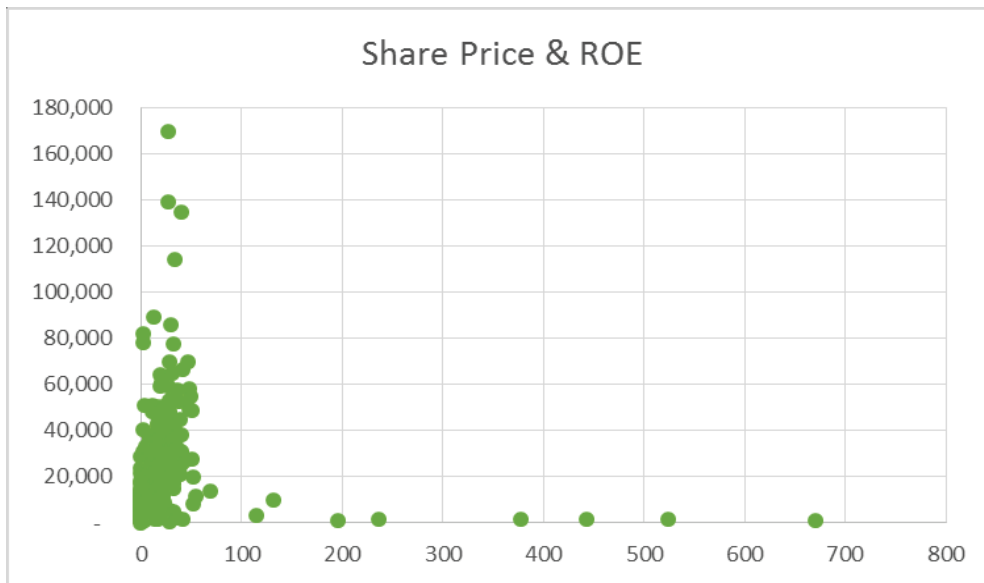
Figure 7. Scatter plot between Share Price and ROE

Share Price Function

Besides determining the correlation degree between share price and some mentioned financial indicators, regression analysis can be used to formulate functions to predict share price. As previously discussed the P/E ratio, and ROE are independent from the share price, hence we will develop two functions based on EPS, and ROA.

To illustrate, the regression analysis reveals that the coefficient of EPS variable (the slope of the regression line) is 4.749795789, meaning if EPS increased by 1,000VND, the share price will increase by approximately 4,749VND. In fact, as a result they-intercept is 5652.779234 when EPS equals to 0, the share price will be 5652.779234 VND.

As a consequence, the function between share price and EPS is:

$$y = 4.7498x + 5652.8$$

               Where:
-      Y: The share price;
-      X: EPS

Similarly, the coefficient of ROA is 1548.487307, and they-intercept 6595.631569. As a result the function between share price and ROA is:

$$y = 1548.5x + 6595.6$$

               Where:
•Y: The share price;
•X: ROA

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More importantly, when testing the developed share price determination function using EPS, the result is quite impressive. To demonstrate, over 60%ofthecalculatedshareprice is less than VND 3,000fromthe actual share price, and another 11% of the expected share price is between 3,000 VND to VND 5,000 from the actual share price.
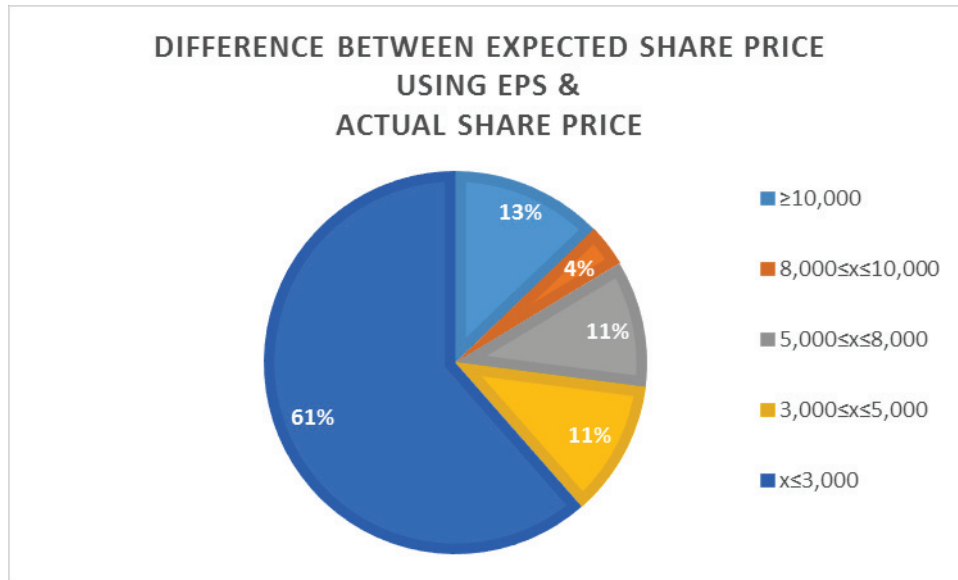
Figure 8. Difference between expected share price using EPS & Actual share price

The result of the function using ROA is slightly less impressive compared to the function using EPS, it is still very acceptablewithjustaround40%,and23% of the calculated price less than VND 3,000; and between3,000 VND to5,000 VND from the actual share price.
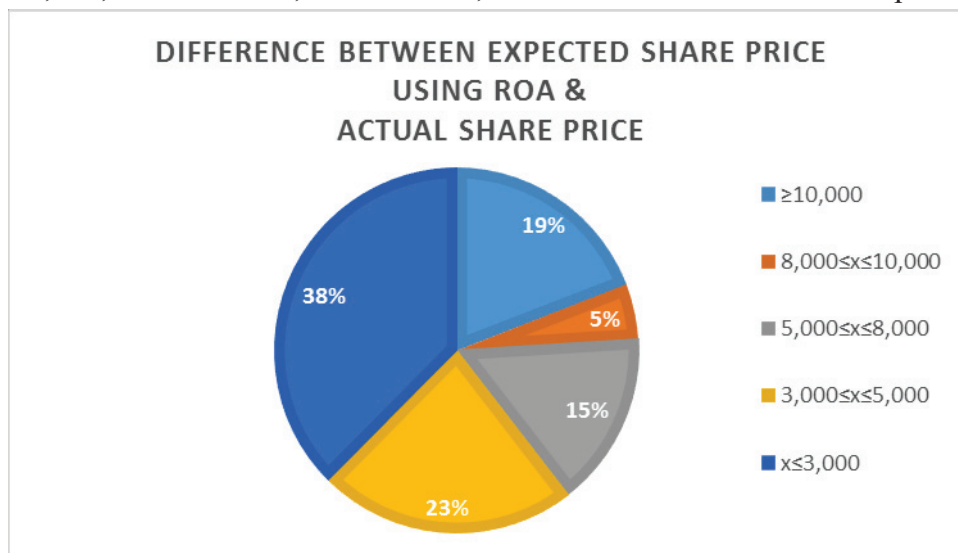
Figure 9. Difference between expected share price using ROA & Actual share price

S2-60

CONCLUSION

In conclusion, based on the data collected from 820 listed companies in the Vietnam stock exchange, even though the ROE, and P/E ratio have almost no effect on the share price; there is a very strong relationship between the share price and EPS, and ROA. Furthermore, the two share price determination models that have been developed gave us additional tools to predict with a certain amount of confidence the future share price in the Vietnam Stock market. The main limitation is that the Vietnam stock market is relatively small compared to the major stock markets in the world as the number of companies and market capitalization is small. More vigorous studies need to be carried out if these findings are to be applied to other stock markets.

REFERENCES

1. Al-Deehani, M, 2003, 'Determinants of Dividend Policy: The Case of Kuwait', Journal of Economic & Administrative Sciences, December, vol.19, no.2, pp. 59-76.
2. Ball, R, Brown, B, 1968, 'An Empirical Evaluation of Accounting Income Numbers', Journal of Accounting Research, vol.7, no.2, pp. 159-178.
3. Cophieu 68, 2014, 'VNINDEX Chart', image, Cophieu 68, 1 January, viewed 1 January 2014, <http://www.cophieu68.vn/chartindex.php?stcid=1&lang=en>
4. Haque, R, Datta, R, Dey, R, Rahman, M, 2013,'Financial Variables Having Significant Impact on Market Price of Shares', Research Journal of Finance and Accounting, vol.14, no.15, pp. 76-80.
5. Kadri, M, Aziz, R, Ibrahim, M, 2009,'ValueRelevanceof Book Value and Earnings : Evidence from Two Different Financial Reporting Regimes', Journal of Financial Reporting & Accounting, vol. 7, no.1, pp. 1-16.
6. Malik, M, Qureshi, M, Azeem, M, 2012, 'Determination of Share Price: Evidence from Karachi Stock Exchange', The Romanian Economic Journal, March, year. XV, no. 43, pp. 97-114.
7. Menaje, P, 2012, 'Impact of Selected Financial Variables on Share Price of Publicly Listed Firms in the Philippines', American International Journal of Contemporary Research, September, vol. 2, no. 9, pp. 98-104.
8. Ohlson, J, 1995, 'Earnings, Book Values, and Dividends in Equity Valuation', Contemporary Accounting Research, vol. 11, no.2, pp. 661-687.
9. Srinivasan, P, 2012, 'Determinants of Equity Share Prices in India: A Panel Data Approach', The Romanian Economic Journal, December, year. XV, no. 46, pp.205-228
10. Uddin, R, Rahman, Z, 2013, 'Determinants of Stock Prices in Financial Sector Companies in Bangladesh-A Study on Dhaka Stock Exchange (DSE)',Interdisciplinary Journal of Contemporary Research in Business, July, vol.5, no.3, pp. 471-480.

11. Viet Capital Securities, homepage, Viet Capital Securities, Hoan Kiem, viewed 1 January 2014, <http://www.vcsc.com.vn/Modules/Analysis/Web/CompanyAZ.aspx?tab=2&cat=5&MenuID=5&subcat=1&lang=en-us>

12. Yen, N, 2011, 'Efficient Market and Signaling Hypothesis on Vietnam Stock Exchange 2006 - 2009', Master Thesis, The College of Buskerud, Norway, viewed 1 January 2014, <http://brage.bibsys.no/hibu/bitstream/URN:NBN:no-bibsys_brage_20684/4/Master2011Nguyen.pdf>

APPENDIX

Descriptive Data

Table 8. Share Price

Share Price	
Mean	14039.5122
Standard Error	546.5821776
Median	9350
Mode	10000
Standard Deviation	15651.73163
Sample Variance	244976703.1
Kurtosis	25.04375952
Skewness	3.972691954
Range	170000
Minimum	0
Maximum	170000
Sum	11512400
Count	820

Table 9. Earnings per Share

EPS	
Mean	1765.703902
Standard Error	81.69979437
Median	964.45
Mode	0
Standard Deviation	2339.526073
Sample Variance	5473382.248
Kurtosis	12.26496021
Skewness	2.638244848
Range	23081.7
Minimum	0
Maximum	23081.7
Sum	1447877.2
Count	820

Table 10. Price Earnings Ratio

PE	
Mean	29.71841463
Standard Error	9.133836819
Median	6.25
Mode	0
Standard Deviation	261.5532824
Sample Variance	68410.11953
Kurtosis	523.5685375
Skewness	21.65314909
Range	6671.4
Minimum	0
Maximum	6671.4
Sum	24369.1
Count	820

Table 11. Return on Equity

ROE	
Mean	13.01841463
Standard Error	1.347111289
Median	6.8
Mode	0
Standard Deviation	38.57539677
Sample Variance	1488.061236
Kurtosis	169.6686496
Skewness	12.06633083
Range	670.8
Minimum	0
Maximum	670.8
Sum	10675.1
Count	820

Table 12. Return on Assets

ROA	
Mean	4.807195122
Standard Error	0.217761556
Median	2.5
Mode	0
Standard Deviation	6.235741983
Sample Variance	38.88447808
Kurtosis	5.563391533
Skewness	2.056292055
Range	43.1
Minimum	0
Maximum	43.1
Sum	3941.9
Count	820

EXTENDING PETRI NETS FOR COST ESTIMATION

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ABSTRACT

Purpose: Petri Nets is a family of modeling formalisms, with different interpretations and abstraction levels; the Petri nets family includes various types of Petri Nets (e.g. classic Petri Net, generalized Petri Net, and the other extensions like Colored Petri Net and Timed Petri Net) that are devised and successfully used to solve various problems involving discrete event systems. However, the Petri Net extensions for cost estimation are still in the beginning stage, and have not been researched or used to convince practitioners to adopt Petri Nets for cost estimation; lack of facilities for cost estimation hinders use of Petri Nets in industrial setting where cost is the major issue.

Approach: This paper starts with Timed Petri Nets, which is an extension of classic Petri Nets, where 'firing time' is added to every transition. This paper further extends Timed Petri nets by adding 'firing costs' too to every transition; by this approach, whenever a transition fires, it incurs not only time but also increases cost of the object ('token') that is handled by the transition. This approach to impose firing costs to transition paves a simple and elegant mathematical approach to enable Petri Nets for cost estimation.

Findings: The extension proposed in this paper is simple to realize yet powerful enough to analyze cost estimation, in addition to the other performance metrics. The proposed extension is realized in GPenSIM - a new tool for modeling, simulation, and performance analysis of discrete event systems. This work also presents a case study that is done with GPenSIM, clearly explaining the elegance and usefulness of the approach.

Originality: The approach to extend Petri Nets for cost calculation is verified theoretically and its use is proven through a case study; for "reproducibility", the whole source code for model discussed in the case study, along with the code for GPenSIM will be made available in a website and its hyperlink will be cited in the reference.

Keywords: Petri nets, cost estimation, GPenSIM

Paper Category: c. Technical paper

THE IMPACT OF E-PROCUREMENT TO ACCOUNTABILITY USING THEORETICAL FRAMEWORKS ON A CASE STUDY

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ABSTRACT

Purpose: This paper aims to observe the impact of e-procurement implementation on the improvement of accountability and examine why those impacts occur by identifying the challenges on the e-procurement information systems in the relation to accountability.

Methodology: This research constructs a theoretical framework, called e-procurement accountability framework to frame the data in observing the impact of e-procurement and applies design-reality gap framework to find out the challenges. Subsequently, this research conducts a case study to demonstrate the use of the framework. The case study was conducted to a province, XYZ Province (anonymous naming) in Indonesia. The majority of data are from primary data based on interview to the stakeholders.

Findings: Our findings show that XYZ province has a moderate impact to accountability since it still need more supports in the terms of institutionalization of e-procurement body, establishing culture of accountability, and creating a well established e-procurement professional.

Implication: As a development from the findings, this research introduces concept of wider e-procurement system that will be useful for other relevant cases as a guidance that we believe mayimprove the impact of e-procurement as part of campaign against corruption, especially in the improvement of the e-procurement accountability.

Practical implications: This paper also recommends three practical suggestions to the XYZ Province government to accelerate e-procurement institutionalization, establish culture of accountability in the wider system and e-procurement professionals.

Originality/value: This case study constructs a new theoretical framework in the current gaps of literature and framework that relates e-procurement and accountability. Hence this

research attempts to introduce a systematical and comprehensive approach in assessing the e-procurement implementation in the relation to accountability.

Keywords: e-procurement, e-government, accountability, transparency, theoretical framework, case study

Classification: case study, conceptual paper

INTRODUCTION

Corruption has been a problem that significantly hampered development in most of developing countries (UNDP, 1999; Olken, 2005). In Indonesia, Jasin (2009) argues that combating corruption still remains as unfinished task since government has not yet fully institutionalized good governance principles.

Among all the sectors, Muqodas (2011), the Chief of Anti-Corruption Commission (Komisi Pemberantasan Korupsi – "KPK") says that procurement sector that still uses conventional procurement was ranked as the most corrupt sector at 43.9 per cent of the total corruption cases handled by KPK during 2004-2011 (VivaNews, 2011). This shows that conventional procurement has many weaknesses since it tends to intermingle with complex and excessive bureaucratic procedures and regulations that are vulnerable for corruption (MDB, 2007).

Following the trend of using ICT to fight corruption, Indonesia has partly started the implementation of online procurement since 2003, changing the conventional procurement system into *electronic procurement (e-procurement*, hereafter*)* to achieve consistent goods and services procurement and also to encourage active public participations by giving constructive input to the governments (Jasin, 2009; SuaraPembaruan, 2013). E-Procurement refers to the application of electronic methods, most typically through the Internet, to facilitate transactions between awarding authorities and suppliers (Davila et al., 2003; OECD, 2006). By 2013, the e-procurement system (or Sistem Pengadaan Secara Elektronik – "SPSE") has been running in all 33 provinces, including XYZ Province, which implemented e-procurement as early as 2010 in almost all of the districts (LKPP, 2014). However, e-procurement is being questioned to be able to give full warranty in diminishing corruption in procurement processes. The leader of Construction Suppliers Union Indonesia argues that the e-procurement system is still doubtful to reduce collusion (Pikiran Rakyat News, 2011). Therefore, to see the effects of e-procurement in increasing accountability and reducing corruption, it is useful to look at the specific case of one provincial government in a developing country in the implementing e-procurement. Subsequently, this paper aims to *observe the impacts* of e-procurement in improving accountability and reducing corruption, as well as to *examine why those impacts occur*.

There are several reasons why it is essential to discuss this specific topic and case. Firstly, this paper aims to contribute and bridge the current knowledge gap in the recent literature regarding e-procurement practices in Indonesia. Moreover, it is essential to investigate this topic, especially in the relation to accountability, whereas in Indonesia the current literature discusses the relationship between e-procurement and transparency, has not yet reached the level of accountability where it is now still more in level of transparency. Secondly, rather than focusing on a nation-wide range, this research proposes to extract data from a particular specific instance of e-procurement in provincial government by exploring XYZ Province. This is useful because obtaining more practical knowledge and lessons learned from a specific case study may assist other e-procurement practices in other countries with similar characteristics within a developing country context. Thirdly, the recent literature has not been discussed e-procurement and accountability in such specific provincial case, especially as the implementation of e-procurement as one of e-Government application in this province is considered new.

THEORETICAL FOUNDATION

eProcurement

It is essential to understand e-government as the background of e-procurement in short before discussing e-procurement in detail. e-Government is the use of emerging ICT, mostly Internet and mobile phones, to deliver information and services for citizens and businesses with the aim to greater efficiency, effectiveness, transparency and accountability of public sector operations (Bhatnagar, 2003; Heeks, 2003; The World Bank, 2011).

Bhatnagar (2003) argues that e-government reduces corruption by reducing opportunities for such as arbitrary action that mostly result in corruption. Furthermore, combating corruption can be undertaken by putting e-government as one of the components of a broader anti-corruption strategy and as service delivery improvement initiative placed in the corrupt department aiming for transparency and reducing corruption.

e-Procurement, as one of e-government solution, promises to help increase transparency that can deterrent corruption (UN, 2011a). e-Procurement is the term used to describe the use of any technology or electronic methods, typically over the internet, to facilitate the acquisition of goods and services by a commercial or government organisations (Davila et al., 2003; OECD, 2006). In general e-procurement systems, the stakeholders consist of three main actors: *suppliers, public and media, and government officials (i.e. government agencies, procurement committees, and e-procurement services).*

Suppliers provide services or goods and *government agencies* acts as the buyers who through *procurement committees* select which services or goods need to be sourced. *e-Procurement services* provide e-tendering services as a mediator between buyers and suppliers. Meanwhile, the *media* monitor the process to ensure checks and balances, and the *public*,

who will be the beneficial of the services or goods provided by government as result of e-procurement, can also monitor the process through e-procurement systems.

Figure 1 shows that e-procurement open more chances for public and suppliers to monitor and control the on going process through e-procurement system. Given the explanation of stakeholders, the following part describes the benefits of e-procurement.

In supplier's sides, e-procurement increases *fairness and competition* by improving access to the government market, stimulating Small-Medium-Enterprises (SMEs) to take part, and improving access to public procurement information (The World Bank, 2003). In public's sides, e-procurement helps public by giving space to *control* procurement processes through online access (The World Bank, 2003). In government's sides, e-procurement works as *anti-corruption tools* by increasing transparency and giving better integration and interaction between government (The World Bank, 2003; UN, 2012b). Figure 1illustrates the relationships and benefits for each stakeholder.
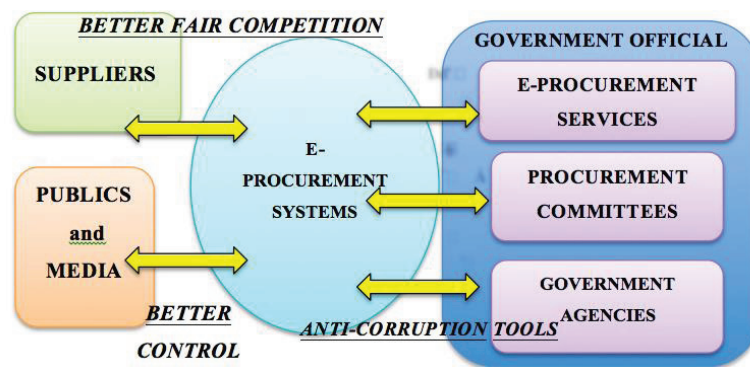
Figure 1 The Relationships and Benefits
(developed from The World Bank, 2003; UN, 2012b)

Relating to our topic, public e-procurement plays an important role as a tool to minimize the risk of corruption and increase integrity (OECD, 2008; Transparency International, 2011). e-Procurement opens the competition in the process of e-GP to the public by allowing real time access information (Neupane, 2012).

Accountability
In the broader context, accountability is under umbrella of good governance. The concept of 'good governance' emerged in the donor discourse arena around 1990s (UN, 2004). In 1998, the former UN Secretary-General Kofi Annan (1998) states, 'Good governance is perhaps a single most important factor in eradicating poverty and promoting development.'

Given that aims, good governance has eight characteristics: *transparency, accountability, participation, consensus oriented, responsive, effective and efficient, equitable and inclusive,*

and follows the rule of law (UNESCAP, 2013). By definition therefore good governance is described as a governance that striving for those eight characteristics (UNESCAP, 2013).

In the light of corruption, governance purposes to corruption by taking into account minorities' view to enrich the decision-making by applying *accountability* and *participation* characteristic (UNESCAP, 2013). Meanwhile, *accountability* refers as to make public servants answerable for government behavior, and *participation* stand as the people gain access to the institution, and *transparency* means the availability of information to general public (Gurung, 2000).

As the foundation for good governance, accountability is the imperative to make public officials both answerable and responsive for government's behavior to the entity from which their derive authority (UNESCAP, 2013). *Accountability* is the process which organization makes a commitment to respond to and balance the needs of stakeholders in its decision-making processes and activities, and delivers against the commitment (GAP Framework, 2005).

The Link Between eProcurement and Accountability
UNPCDC (2010) argues that accountability is the central pillar of any public procurement system by strengthening the government's good or services sourcing. There are several countries that have experienced increment of transparency and reduction of corruption opportunities as result of e-procurement, for instance Chile, as developing country like Indonesia (UNPCDC, 2010).

In Chile, the weak procurement control mechanism forced public procurement in Chile to establish e-procurement system namely ChileCompra, which allows suppliers and public agencies to give feedback, increases corporation and reduces opportunities for corruption (Orrego et al., 2000). Therefore, e-procurement is believed to increase transparency in public procurement, thus leads to greater accountability (UNPCDC, 2010).

As mentioned earlier, accountability cannot be enforced without transparency. There is little doubt that under some condition, increased transparency in public procurement may lead to greater accountability (UNPCDC, 2010). However, it is argued that transparency is considered as a highly cost-effective way to greater accountability (Schapper, 2008). This argument is in agreement with Heeks's (2012) concept of the Ladder of Accountability that can be seen in the following section.

THEORETICAL FRAMEWORKS

Framework of eProcurement Impact to Accountability
Recent literature still discusses accountability or e-procurement separately. Hence, this research tries to fill the gap by purposing a developed e-procurement and accountability

conceptual framework based on recent relevant literatures. This e-procurement accountability framework consists of *three steps of accountabilities ladders, performances indicators*, and *three categories of performances indicator*. Generally, each accountability ladder is measured using several performances indicators within different categories of performances indicators.

Heeks (2012) defines accountability as a ladder of steps consists of: *publication, reporting, and transparency.* In *e-procurement*, *publication* means there is provision of basic information such as office contact information, tender opening details, and so forth. *Reporting* provides specific details on the decisions and action, for example, which supplier wins the tender, and which does not win. *Transparency* is not only concerned about basic information to citizens, but also providing some comparisons between government targets and achievements, for example a graphical information comparing the target for a procurement budget project with the real budget realization in a given period. In the highest ladder step, *accountability* is reached when the citizens can control the result by questioning the decision and giving rewards or punishments to public servants. Therefore, the public servants are accountable for what they have done and how they spent the public money.

To explore specifically on the impact of e-procurement on accountability, this research develops performance indicators for each ladder gaining from four related sources: Global Accountability Project (GAP) Framework published by One World Trust (2005), Bovens (2006), Accountability Framework formed by United Nations (UN) (2011), and Commonwealth Procurement Rules (2012) by Australian Government. Those four sources discuss public sector organization hence it is relevant with research's case study.

Each ladder of accountability should be integrated into organization's policies, procedures, and practices. Thus, in general, every ladder of accountability step consists of three different categories: *policies, processes,* and *practices*. The integration of the three steps of accountability ladder, performance indicators, and three categories can be seen in Table 1.

Table 1 eProcurement Accountability Framework Source: developed from GAP Framework (2005), Bovens (2006), UN (2011), Commonwealth Procurement Rules (2012)

Ladder Step 1: Reporting e-procurement

Policies: Information Provision and Recording Policy
There is policy that regulates the activities of reporting. *Reporting e-procurement* is based on both *provision and recording of its information*. *Provision of e-procurement informationpolicy* regulates the channels and how the details in *providing information* to the public, especially to the suppliers. *Recording of e-procurement informationpolicy* regulates and protects the e-procurement documentation to be available for the benefits of public (GAP Framework, 2005; Bovens, 2006).
Processes: Information Provision and Recording
There is procedure or rule that defines the conduct of both information provision and recording.

> **Practices: Proper Information Provision and Recording**
> ▪ *Information* is *reliable, understandable, accessible, and timely* to stakeholders. *Reliable* means that the information is accurate and authorized, *understandable* relates with familiarity with the language and format, *accessible* is easy to access for example through website portal, and *timely* means the provision of information within sufficient time to make decision (GAP Framework, 2005; Bovens, 2006; Commonwealth Procurement Rules, 2012).
> ▪ *Properly maintain appropriate recording* for each procurement to provide accurate and concise information (Commonwealth Procurement Rules, 2012).

Ladder Step 2: Transparency e-procurement

> **2.1 Policies: Information Disclosure Policy**
> There is policy that regulates the information disclosure to ensure meaningful and consistent transparency (GAP Framework, 2005; UN, 2011)

> **2.2 Processes: Benchmarking**
> There is process that defines the mechanism to compare e-procurement performances relate to set targets (Heeks, 2012).

> **2.3 Practices: Proper Access to Performance**
> Public is able to access the performance for example how e-procurement progressing (GAP Framework, 2005).

Ladder Step 3: Accountability e-procurement (includes all points in Step 2)

> **Policies:Culture of Accountability**
> There is policy that regulates or, at least, facilitates the building of perception of accountability culture to be embedded in each individual public servant. (UN, 2011).

> **Processes: Active Participation**
> There is established mechanism that details procedure on the role of participation in decision making for all stakeholders, for example time period for appealing the tender result or providing mechanism of complaint (GAP Framework, 2005)

> **Practices: Proper Acted upon Complaint and Response**
> There are activities to properly reviewed, investigated and acted upon complaint within established timelines (GAP Framework, 2005; UN, 2011). To maintain the accountability quality, internal control should be conducted such as performance assessment or whistle blowers (UN, 2011).

This research proposes four categorizations to conclude the impact of e-procurement on accountability. The categories are ranging from *strong impact, moderate impact, low impact,* to *no impact*. In each category, there are several conditions. The description of each categorization can be seen on Table 2.

Table 2 Category for Impact of e-Procurement on Accountability

Strong Impact	If meet one of these conditions: a. There are almost no gaps between policies and processes and practices in accountability, or b. Most of findings in accountability step are found.
Moderate Impact	If meet one of these conditions: a. There are some of the findings on accountability steps (among policies, processes, and practices), or b. There are only some gaps in accountability step, or c. Most of findings in reporting and transparency ladder are found.
Low Impact	If meet one of these conditions: a. There are only few findings in accountability steps are found, or b. There is no match in accountability between policies, procedures and practices, or c. Some of findings in reporting and transparency are found.
No Impact	There are very few findings on reporting and transparency.

Framework for Evaluating Behind the Impact on Accountability

To identify the challenges, this study attempts to find out factors that contribute to the result by looking in e-procurement processes the gap between reality and design proposal of e-procurement for each dimension. According to Heeks's (2008), design-reality gaps, the dimensions in the information systems that need to be identified challenges are *information, technology, processes, objectives and values, staffing and skills, management systems and structures,* and *other resources*. In each dimension, the bigger gap between proposed designs with reality, the bigger challenges occur.

Firstly, *information* needs to be reliable, understandable, accessible and timely to e-procurement stakeholders (Bovens, 2006; UN, 2011). Secondly, *technology* needs to be able to protect the confidentiality of data and avoid from data lost. According to Commonwealth Procurement (2012), to provide reliable (i.e. accurate and concise information), appropriate maintenance of records and documentation is essential. Thus, the technology and system need to be up and running and also secured from threats (i.e. hacker or vulnerability of data loss). Thirdly, in terms of *processes*, e-procurement should be equipped with policies, a clear statement, standard operating procedures (SOP) to guide e-procurement practices in defining "what needs to be done" and "how to do it" to uphold accountability. Fourthly, *proper reporting, transparency and accountability* are set as *objectives* of the e-procurement system, while *culture of accountability* is manifested in the perception between public servants and public sector's leadership as *values* (UN, 2011). As mentioned previously, to measure the achievement of objective and culture, general guideline can be used such as performance assessment, ethics policies, and rewards and sanctions mechanisms. Specifically for this case, those regulations might include such as confidentiality guidance, information disclosure, procurement SOP, complaint procedure, and so forth (GAP Framework, 2005; Commonwealth Procurement, 2012).

Fifthly, the public servants must have appropriate *skills* to manage the e-procurement process to uphold accountability. The skills should cover both the nature of e-procurement and accountability such as operating computer and accessing Internet. Meanwhile, the nature of accountability is related to reporting, transparency, and accountability, i.e. acting on complaints and giving responses. Sixthly, in *management systems and structures*, the leader has to show strong leadership to encourage and enforce the culture of accountability and regulation (UN, 2011).

In the wider system, this must involve the entire leadership in the entire process of e-procurement, for example the public agencies, procurement committees, e-procurement services, governor, or even the president (UN, 2011). The existing organization structure facilitates the enforcement of an accountability culture (UN 2011). Mostly, the organization should adjust as needed by changing of the work structure, for example there might be a need to establish an independent e-procurement services. Finally, there must be adequate *resources* (i.e. time, money, political situation) to support accountability. To assess the Design-Reality gaps, these research categories the gap into *very low, low, low-medium, medium, medium-large, large, very large* (Heeks and Bass, 2011) based on the comparison of the gap between the e-procurement design proposal and reality.

METHODOLOGY

This study can be categorized as *basic research* since it seeks to improve understanding in specific e-procurement and accountability issues, rather than to provide a solution to a specific problem (Bryman, 2004). Since this research attempts to explore in detail the practice of e-procurement in XYZ Province, a case study is the most appropriate method.

This research selected XYZ province for three main reasons. Firstly, compared to other Indonesian provinces, XYZ Province has good potential of e-government as it had a good ranking in the e-government awards despite being located in one of the lowest Internet ranked areas for Internet penetration. Secondly, they have targeted to have all the procurement to be conducted electronic in the end of 2013, and by 2012 XYZ province has already moved 32% of total procurement to e-procurement. Hence the data is already available as a sample. Finally, since Indonesia is categorized as a developing country, the case study provides a typical developing countries context that might be a relevant to similar characteristics of provinces in others developing countries (Yin, 2009).

With regard to the case study selection, this research conducts both *primary and secondary data.* To ensure the reliability of data, *triangulation*, i.e. combining data from different sources and methods (Heeks, 2008) is used. To facilitate triangulation, in term of sources, this study looks at policies or regulations at national level, policies at provincial level, and involves individuals within and surrounding the e-procurement process to provide primary or

secondary data (Morgan, 2012). In terms of methods, this study applies two different methods, interviews and document analysis (Creswell, 2007; Yin, 2012). The primary data are collected through *semi-structured interviews*, while the secondary data are gathered from *document analysis.*

XYZ Province's E-Procurement Profile
1)Regulation
Nationwide, several regulations have been established that provide jurisdiction, guidance, or support in conducting e-procurement. In terms of jurisdiction, the issued President Decree No. 54 of 2010 on Government Procurement focuses on e-procurement. This decree has been renewed twice, into No. 35 of 2011, and most recently No. 70 of 2012. This regulation requires every national and local government to conduct e-procurement services named *LPSE*.

To support transparency in e-procurement, Constitution No. 14 of 2008 on Public Information Disclosure was legalized aiming to protect the public rights in requiring public information in order to optimize public monitoring of state administration that has an impact on public interest. Regarding e-procurement digital document, Constitution No. 11 of 2008 on Information and Electronic Transaction protects any information and electronic transaction, including electronic documents. Besides regulation, to support e-procurement practice, LPSE teams were also established to conduct e-procurement.

2)XYZ eProcurement Stakeholders
XYZ Province LPSE responsible to maintain local e-procurement system (*SPSE*, hereafter)and works as administrator for supplier registration and verification. In each XYZ Province agency, *procurement committees* (PCs) held the procurement processes, including select the winning suppliers and response for objections and appeals through SPSE. Moreover, LKPP, as central government, supports and monitor local SPSE and the whole procurement processes. Figure 2 illustrates the relationship of e-procurement stakeholders.
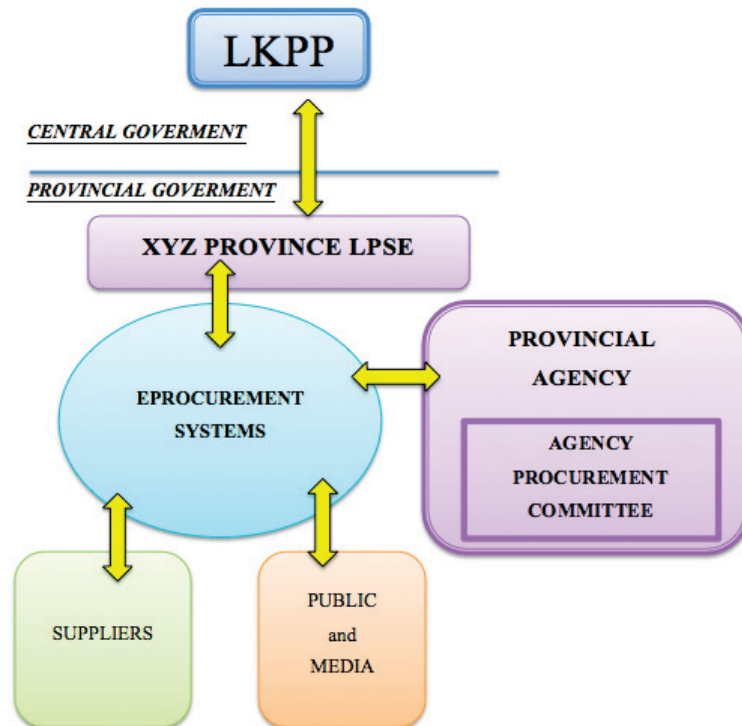
Figure 2 XYZ Province eProcurement Stakeholders (developed from interview, 2013)

3)eProcurement Processes

The XYZ Province SPSE, not only can be used for local procurement processes, but users or suppliers can also bid another procurements in any ministry, government agency, or government institution that run SPSE as their e-procurement systems. The e-tendering process, as the most important e-procurement processes can be seen on Figure 3.

Figure 3 LPSE XYZ Province eProcurement Process(PC, interview, 05/08/2013; GoI, 2012)

Firstly, the PC posts the procurement project details through SPSE to *open* the tender and *invite* the suppliers. Secondly, in *the registration*, XYZ Province LPSE gives unique login identification (ID) for accessing SPSE. Suppliers only need to register once and then they can join e-procurement in any LPSE in Indonesia. Thirdly, to ensure *the validation* of the supplier's documents whether they own the valid business permit document, suppliers must show the original document to LPSE verification staffs.

Fourthly, suppliers *submit* the document by uploading to the portal within a restricted duration. The PC examines the offer documents through SPSE without knowing who the suppliers are by using anonymous names. Fifthly, the winning supplier is *announced* on the portal homepage that can be accessed to public. The reasons for the rejected suppliers are also provided. Next, the objection period and objection appeal is announced on the portal hence any suppliers that joined certain e-tendering or others suppliers or even public can follow the process.

ANALYSIS RESULT

Findings: eProcurement Impact on Accountability

Most of the performance indicators in reporting and transparency ladder have been found. However, there are some gaps in accountability steps. In *reporting and transparency*, most of the performance indicators have been found in each category. The policies are mostly based on President Decree No. 70 of 2012, where the processes are defined by LKPP. Compared to the practices of *reporting* performances indicators, the suppliers admit that the information has fully the quality as reliable, timely, accessible and understandable. The recording of digital document or non-digital document also has been conducted properly. Thus, most of reporting ladder's the performance indicators in those areas have been found.

In *transparency*, the policies and processes have been adequately defined. In terms of policies, nationally, Constitution on Public Information Disclosure protects the right of public for transparency in any government activities including e-procurement. Provincially, XYZ Province has a Transparency Regulation that regulates to specific context of XYZ provinces governmental activities including e-procurement. The details process of transparency has been defined well in the e-Monitoring mechanism that includes procurement progress report. Although in practice, XYZ Province still has to work on some technical error that delayed progress on the reporting. Nevertheless, XYZ Province LPSE still continuously reports to the central government manually. Thus, most of performance indicators have been found in policies and processes, although in practices should be improved.

Furthermore, in *accountability*, some performance indicators have been found in the policies and processes area, which are quite well defined. Examination on President Decree No. 70 that regulates the objection period and appeal on the e-procurement result shows commitment from the governments. However, *culture of accountability* needs more than just a channel for

suppliers and public to argue with government, it also requires a daily habit of public servant to be accountable. Government needs to address it through processes for example through performance assessment, ethics policies, rewards and sanctions mechanism specifically designed to maintain accountability throughout the process of procurement. Currently, the processes have been quite effective in defining the detailed mechanisms of complaint to each official, LPSE, LKPP and PC. Furthermore, whistle blowers system has been regulated through the Head of LKPP Regulation.

In practice, the culture of accountability is still difficult to be created and maintained since XYZ Province's LPSE and PC is still an ad hoc committee. By having ad hoc committee, it may lead to the lack of permanent salary and internal control. This argument is also supported by some suppliers that are still dissatisfied with results from some of PCs that gave unrealistic procurement specification to suppliers or unsatisfactory objection explanation. These arguments, combined with the situation that PC status remains ad hoc, may be a good indicator that the culture of accountability should be strongly considered. Thus, some of the requirements are found to be satisfied in each area, but accountability requirements have been found not to be adequately mature.

Referring to literature review, looking at the categorization of the impact of e-procurement on accountability, most of the requirements set out in the reporting and transparency ladder were found, although only some of the requirements in accountability were found. The evidence therefore meets the two conditions for *moderate impact*: (a.) Some findings on accountability steps are found (i.e. policies and processes), and (c.) Most of findings in reporting and transparency ladder are found. Thus, the e-procurement in XYZ Province has been providing *moderate impact on the accountability* of the government.

Findings Discussions: Evaluation of The Impact on Accountability
As mentioned in literature review, Design-Reality Gaps has seven dimensions, i.e. *information, technology, process, objective and values, staffing and skills, management systems and structures, and others resources* around e-procurement system that needs to be appropriate for accountability. The analysis of gap for each dimension describes consecutively as follows.

As discussed in previous section, *the information* has been qualified to the stakeholders (Suppliers, 2013). However, sometimes, due to human error, there was the case that PC entered wrong information of offering document duration (PC, interview, 05/08/2013).

In *technology and infrastructure*, LPSE staffs confirmed issues of Internet and electricity supply that are still troublesome on several occasions during peak Internet traffic. Bottlenecks often happen since many suppliers upload the offering document at the same times (LPSE Administrator, interview, 19/07/2013). In terms of electricity, sudden electricity shutdown often occurs in XYZ Province. Although the application is already secured, the electricity and

Internet connection has not been fully providing the full service to support e-procurement. Thus, the gap is medium.

In terms of *policies*, although in some cases the formal processes have been formalized, the enforcement of procedures still needs to be improved. Seeing that most of legislation and procedures has been settled, hence, the reality compare to the design proposal has shown that the gap is small.

In *objective and values*, though in LPSE and LKPP the culture of accountability has been shown and felt, nevertheless, some of PCs are still lack of culture of accountability. As argued by Supplier 1 (interview, 21/06/2013) who points out, 'e-Procurement is only a system as prevention to reduce the number of corruptions, it cannot prevent person intention for corruption.' Even though, the objective of this new procurement system has been disseminated throughout the officers, including how transparency and accountability have became the main objective. Thus, the gap is medium-large.

In the *staffing and skills*, in terms of recruitment, LPSE and PC has some challenges since it is still an ad hoc committee where they are still part of the agencies with multi tasking with their main duty. LPSE Helpdesk (interview, 12/08/2013) argues that the workload is overwhelming since it is a mix of her main duty from the agency and LPSE work duty. Similarly, PCs are not focused on their job, so in some cases the committee are not give its best performance, i.e. forgot to check supplier's offer document in time, affecting the whole procurement schedule (LPSE Administrator, interview, 19/07/2013)Moreover, the salary is very low compare to the difficulties and risks of the duty, which make many potential members of PC uninterested. In terms of skills, the skills of official government are difficult to be developed since it is lack of PC institutionalization (Practitioner, interview, 23/08/2013), although the lack of skills has been minimized through intensive training. Due to incompleteness of institutional status, the staffing and skills management cannot be performed as designated by the President decree. Therefore, the gap on this dimension is medium-large.

In *management systems and structures*, it needs strong leadership to encourage and enforce the culture of accountability and regulation, and the existing structure has to support the culture of accountability. Some suppliers argue that the governor has been giving sufficient support and contributes to the success of e-procurement in reducing corruption and increasing public participation. However, some suppliers disagree with that fact, rather than arguing that most of the leaders provide support only in writing (Suppliers, interview, 2013). The management and structure in LPSE and procurement structures have not been established as the design proposal. It is still ad hoc. However, this situation is understandable by the practitioner (interview, 23/08/2013) who points out, 'Official government is still on the track, it is difficult to establish a perfect system in short time, as we're aware that LKPP is still 6 years establishment where provincial LPSE haven't been 3 years on going.' Seeing, the ad

hoc management and structure can still carrying on going e-procurement, thus, the gap on this dimension is medium-large.

In *other resources*, the budget given on interviewee's agency is not adequate to provide proper salary budget, training, and regeneration activities. Comparing the design proposal with reality, the gap is medium.

Findings Implication: E-procurement Wider Systems
Moreover, e-Procurement systems involves not only on how well the technology works, i.e. an e-procurement online portal that is sophisticated, free of bugs and accessible, but also on wider systems. From this case study, this research finds that e-procurement is only one of the steps in aiming for improved accountability. E-Procurement needs to be supported by the wider systems around it. The wider systems might include other systems that serve the procurement process, i.e. the systems of the PC, procurement regulator, procurement official unit and provincial government systems. Thus, the term is called 'E-Procurement Wider Systems'.

The impact of moderate accountability is the result of the each system maturity in terms of existences of policies, processes, and its practices. This wider e-procurement system can be described in the form of a 'full model of e-government systems' (Heeks, 2006). This full model consists of several layers. Adapting from this model, this wider e-procurement system is illustrated in Figure 4.
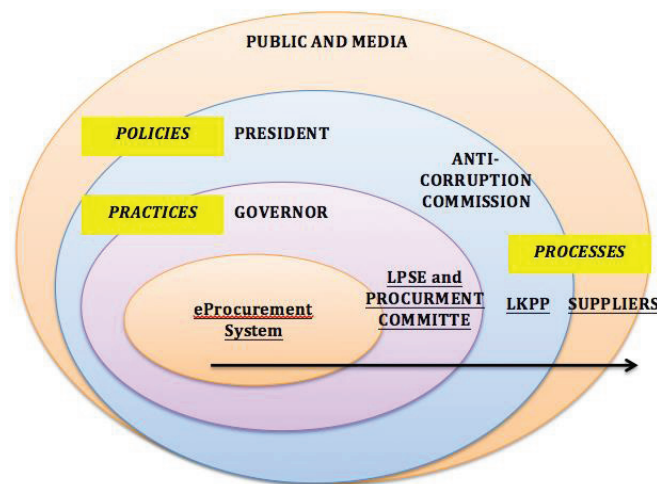
Figure 4 eProcurement Wider Systems (developed from Heeks, 2006)

Figure 4 proposes an argument that e-procurement is on the inner layer as *information systems* layer, while in the outside layers there are many other systems that influence this e-procurement system. In *practices*, provincial government, which is lead by the Governor, need to have capacity to conduct proper e-procurement. Mean while, central and provincial governments who regulate *policies and processes* are in *organization* layers. At the outer

layer, suppliers, public and media must have a space to monitor the conduct of government as *environment* layers.

Furthermore, this completely wider system might have significant impact on the use of ICT for government purposes. E-procurement, as one of e-government application, may enhance the national e-government readiness. Therefore, many countries have points out e-procurement as priority of e-government agenda (Aman and Kasimin, 2011). According to the UN's Global Survey on Indonesia's e-government Readiness 2012 states that Indonesia has an improvement on e-government by step up to rank 97 out of 190 (UN, 2012a), where the position was lower in 109 out of 190 by two years ago (UN, 2010). Nevertheless, Indonesia infrastructure index is still lower than the world's average (i.e. 0.190 compare to 0.326) (UN, 2012). Hence, the provincial e-government's infrastructure is shown to need more attention since it might have quite significant implication to the accountability in the context of e-procurement.

In addition, Indonesia e-procurement system, that has been implemented in 33 provinces and 731 agencies (LKPP, 2014), has not shown a major impact on reducing the number of corruption. Indonesia's corruption perception is in the position 117 out of 177 countries (Transparency International, 2013). It leads to the fact that the perception of corruption is still high which might impact to the higher challenge in building the culture of accountability. This may explain the findings discussion in the previous section which indicates the culture of accountability is low.

RECOMMENDATION

Conclusion

It has been found to be a *moderate impact to accountability*. Most of the performance indicators are found in reporting and transparency ladder, while some of them are found in accountability steps. Most of the performance indicators in reporting and transparency have been defined through policies and processes, then in practices most of it has been undertaken well. However, in *accountability* ladder, even they have already defined the kind of accountability by having control of a two-ways interaction with public or suppliers, some of procurement committee have not been satisfying to the suppliers. Moreover, culture of accountability is still difficult to be created and maintained since XYZ Province's LPSE and PC is still an ad hoc committee.

The moderate impact on e-procurement is most likely to be influenced by major challenges with medium-large gaps between the design proposal and the reality in three dimensions: (1) *the objectives and values*, (2) *staffing and skills*, and (3) *managements and structures* within this e-procurement systems. Overall, the low Internet penetration has not been the main challenges on the improvement of accountability. Hence, this research argues that if the province has good potential in e-government, it also has more opportunities to increase

accountability by establishing capacity of its government official while also improving the technology infrastructure.

Practical Recommendation

There are three main improvements that suggested to be addressed: ***acceleration of e-procurement institutionalization, establishment of culture of accountability in e-procurement wider system, and establishment of e-procurement professional.***

Institutionalization is the first thing that needs to be in place. The leader of XYZ Province is urged to accelerate the e-procurement official institutional settlement. Seeing the fact that e-procurement cannot stand alone without the establishment of other's system surround it, LPSE and PC should be an independent institution. By having a status as institution, the staff can have be more *focus, better salary, better control from internally and externally parties, and better culture.*

There are several ways to change the old culture of corruption to increase ***the culture of accountability***. Firstly, by giving *good example* from the leader, top managements and also the staffs. Secondly, bringing *habit of accountability settlement* through training, regeneration, or jargons like 'No for corruption'. Thirdly, *another tools* such as *award and punishment*, whistle blower, or peer-to-peer evaluation (UN, 2011; Practitioner, interview, 23/08/2013). In the respect of e-procurement, the skills that need to be built should not only surround skill of IT, but also ***professional training*** to establish the culture of accountability. As the Procurement Service Unit has just established, the officers are being recruited and trained to be a professional who is skilled, competent, and gained pride to be a PC.

Lesson Learned

Firstly, e-procurement should be seen as part of a wider system and it needs to link to other instruments within the wider system. In this case, the wider systems consist of the *e-procurement service unit* who serves and maintains the application, *procurement committee* who deal with the procurement processes, *procurement regulator* who establishes the procurement regulation, *provincial government* that is responsible for the whole activities, and *central government* that establishes the main policy. It is necessary to be aware that a secure and sophisticated e-procurement system is only a part of success in improving accountability.

Secondly, it is important for institutional settlement to be well managed before going further. Based on the constitution, the provincial government might be at ease since the obligation to institutionalize the procurement committee still has until 2014, while the deadline for LPSE is still undefined. However, it is essential to institutionalize all the elements in the wider system. As institutions, they can have a better focus on doing their procurement duty, better control, better staffing, better salary, and a better culture of accountability as well.

Thirdly, accountability is not only about building a system, but also a culture. Building a system, procedure, or tools for upholding accountability are elements of success. However, accountability, if not understood and embedded in the public service mindset can only last as an ideology, not as a habit. Accountability needs to be a culture of habit, to be part of the perception of the public servant role. Thus, e-procurement is just a step toward accountability. It can help to drive the culture of accountability, but humans themselves are the main actors for building that culture.

Future Research Suggestion

Despite of the findings and ability to answer the research question, this research still has some limitation that better to be addressed in future research in this field. The future research can conduct deeper investigation when XYZ Procurement official has been institutionalized to see how the establishment of performance assessment, reward and sanction, or whistle blower system might impact more on accountability.

<div align="center">REFERENCES</div>

1. Aman, A.,Kasimin, H.(2011),"E-procurement implementation: a case of Malaysia government", *Transforming Government: People, Process and Policy*, Vol. 5 No. 4, pp. 330-344.
2. Bhatnagar, S. (2003), "Transparency and corruption: does e-government help?", *Compilation of CHRI 2003 Report OPEN SESAME: Looking for The Right to Information in Commonwealth.*
3. Bovens, M. (2006), "Analysing and assessing public accountability a conceptual framework", *European Governance Papers*, No. C-06-01.
4. Bryman, A. (2004), *Social Research Methods*, Oxford University Press, Oxford.
5. Commonwealth Procurement Rules (2012),*Commonwealth Procurement Rules,* Department of Finance and Deregulation, Commonwealth Procurement Rules Government.
6. Creswell, J. W. (2007),*Qualitative Inquiry and Research Design, Choosing Among Five Approaches,* 2nd edn, Sage, USA.
7. Davila A., Gupta, M., Palmer, R. (2003), "Moving procurement systems to the internet: the adoption and use of e-procurement technology models", *European Management Journal*, Vol.21 No.1, pp.11-23.
8. GAP Framework (2005),*Pathways to Accountability The Global Accountability Project (GAP) Framework*, One World Trust, London.
9. GoI (2012),*President Decree of Number 70 of 2010 on Government Procurement,* Government of Indonesia, Jakarta, Indonesia.
10. Gurung, SM. (2000), *Good governance, participation, gender and disadvantaged groups* [Online], Available: http://www.nssd.net/pdf/nep03.pdf (Accessed: 25 July 2013).
11. Heeks, R. (2003), 'Most eGovernment-foro-Development Projects Fail: How Can Risks be Reduced', *iGovernment Working Paper Series no.14*, Institute for Development Policy

and Management, Manchester.

12. Heeks, R.B. (2006),*Implementing and Managing eGovernment,* Sage, London.

13. Heeks, R. (2008),*Researching ICT-Based Enterprise in Developing Countries: Analytical Tools and Models,* Development Informatics Working Papers, No. 30, IDPM, University of Manchester.

14. Heeks, R. (2012),*e-Citizens: Connecting Citizens and Government,* e-Government course unit handout, IDPM, University of Manchester, Manchester, 02 Oct.

15. Heeks, R., J. Bass. (2011), "Changing computing curricula in African universities: evaluating progress and challenges via design-reality gap analysis", *Electronic Journal of Information Systems in Developing Countries*, Vol. 48 No. 5, pp.1-39.

16. Jasin, M. (2009),*The Pattern of Eradications of Systemic Corruption through Prevention And Action* [Pola Pemberantasan Korupsi Sistemik Melalui Pencegahan dan Penindakan]*, Information System of State or Provincial Lost, Bureau of Financial Investigation [Online], Available: http://sikad.bpk.go.id/nw_detail.php?n_id=18 (Accessed: 14 May 2013).

17. LKPP (2014), *LPSE Implementation Progress* [Progres Implementasi LPSE 2008-2014], Lembaga Kajian Pengadaan Barang/Jasa Pemerintah (LKPP) [Online], Available: http://report-lpse.lkpp.go.id/v2/beranda (Accessed 15 April 2014).

18. Morgan, S. (2012),*Conducting Information Research,* Research Skills for Development hand out, IDPM, University of Manchester, Manchester.

19. MDB (2007), *Multilateral Development Bank International Survey E-Procurement Systems,* The Procurement Harmonization Project of The Asian Development Bank, The Inter-American Development Bank, The World Bank, The Curtin University of Technology Business School, and International Governance Solution Ltd [Online],Available:http://ec.europa.eu/internal_market/publicprocurement/docs/eprocurement/mdb_egp_survey_en.pdf [Accessed: 29 October 2012].

20. Neupane A., Soar, J., Vaidya K., Yong, J. (2012), 'Role of public e-procurement technology to reduce corruption in government procurement', *International Public Procurement Conference,* Washington.

21. OECD (2006),*E-Procurement Overview,* Organisation for Economic Co-operation (OECD), Jan.

22. OECD, A (2008), *Fighting Bribery In Public Procurement In Asia-Pacific* [Online]. Available   at http://www.etransform.org/gti/sites/etransform.org/files/Documents/bribery.pdf. [Accessed: 03 June 2013].

23. Olken, B. A. (2005),*Monitoring Corruption: Evidence from a Field Experiment in Indonesia,* National Bureau of Economic Research, Working Paper, no. 11753.

24. Orrego, C. with Osorio, C., Mardones, R. (2000), Chile's Government Procurement E-System. The World Bank [Online], Available: http://go.worldbank.org/0QQ3Z9HT61 [Accessed: 27 August 2013].

25. Pikiran Rakyat News (2011),*No warranty of E-Procurement Cannot Warranty Free From Collusion* [E-Procurement Tidak Menjamin Bersih Dari Kolusi], Pikiran Rakyat

[Online], Available: http://www.pikiran-rakyat.com/node/154985(Accessed: 8 March 2014).

26. Schapper, P. (2008), 'The impact of e-procurement on corruption: The potential of e-procurement for curbing corruption risks', paper presented at 7th regional seminar on making international anti-corruption standards operational, Indonesia.

27. SuaraPembaruan (2013),*President pushes MoU of Procurement Corruption Eradication* [Presiden Dorong MoU Pemberantasan Pengadaan Barang], Suara Pembaruan Newspaper [Online], 11 Mar., Available : http://www.suarapembaruan.com/home/presiden-dorong-mou-pemberantasan-korupsi-pengadaan-barang/32083 (Accessed: 14 May 2013).

28. The World Bank (2001),*Decentralisation and Subnational Regional Economics*, The World Bank Group (Online), Available: http://www1.worldbank.org/publicsector/decentralization/what.htm [Accessed: 10 July 2013].

29. The World Bank (2003),*Electronic Government Procurement (e-GP),* The World Bank, Washington, US.

30. Transparency International (2011) 'Combating Corruption in The EU Through eProcurement', Transparency International [Online], Available: http://blog.transparency.org/2011/02/16/combating-corruption-in-the-eu-through-e-procurement [Accessed: 01 June 2013].

31. Transparency International (2013),*Corruption Perception Index 2013* [Online], Available: http://cpi.transparency.org/cpi2013/results/ [Accessed: 13 April 2014].

32. UN (2004),*Commitment To Good Governance, Development, and Poverty Reduction: Methodological Issues in The Evaluation of Progress at National and Local Levels,* Sixth Session of The Committee on Development Policy, March-April, United Nations, Thailand. Available at: www.un.org/special-rep/ohrlls/ldc/Workshop/Monitoring good governance.pdf. [Accessed: 20 August 2013].

33. UN (2011),*Accountability Frameworks in The United Nations Systems,* Join Inspection Unit, United Nations, Geneva.

34. UN (2011a),'E-Procurement: Towards Transparency and Efficiency in Public Service Delivery',* report to the expert group meeting, Department of Economic and Social Affairs, United Nations [Online], Available: http://unpan1.un.org/intradoc/groups/public/documents/un/unpan047627.pdf (Accessed: 14 May 2013).

35. UN (2012),*Indonesia E-Government Development Index* [Online], Available: http://unpan3.un.org/egovkb/profilecountry.aspx?ID=78 (Accessed: 13 April 2014).

36. UN(2012a),*United Nations E-Government Surveys 2012* [Online], Available: http://unpan3.un.org/egovkb/datacenter/CountryView.aspx (Accessed: 13 April 2014).

37. UN (2012b),*UN Procurement Practitioner's HandBook,* United Nations,New York, Nov.

38. UNDP (1999),*Fighting Corruption to Improve Governance,* Management Development and Governance Division, United Nations Development Programme, New York.

Proceedings of 2014 International Conference on
Technology Innovation and Industrial Management
28th-30th May 2014, Seoul, South Korea

39. UNESCAP (2013),*What is Good Governance,* United Nations Economic and Social Commission for Asia and the Pacific, Thailand.

40. UNPCDC (2010), *Accountability in Public Procurement – Transparency and The Role of Civil Society*, United Nations Procurement Capacity Development Centre (Online), Available: http://www.unpcdc.org/media/142496/story%20of%20an%20institution%20-%20accountability.pdf [Accessed: 20 August 2013].

41. VivaNews (2011),*Busyro: 43% Corruption from Procurement* [Busyro: 43% Korupsi dari Pengadaan Barang], VivaNews [Online], Available: http://us.bola.viva.co.id/news/read/265372-busyro--43--korupsi-dari-pengadaan-barang (Accessed: 14 May 2013).

42. Yin, R.K. (2009),*Case Study Research: Design and Methods*, 4th edn, Sage, CA.

43. Yin, R. (2012),*Application of Case Study,* 3rd edn, Sage, USA.

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COST STRUCTURE ASSESSMENT OF COLD CHAIN ALONG THE SUPPLY CHAIN FOR THAI MANGO

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ABSTRACT

Mango, a foremost export fruit of Thailand, is exported to many overseas markets, including markets with both high and low purchasing powers. Thailand is ranked third among the world's leading exporters by volume. The main problems which hinder competitiveness of Thai mango among its competitors are lack of output consistency, inefficient management of production data, high production costs, lack of control over use of chemicals, lack of technology applied to the production and distribution systems, and higher distribution prices when compared to competition. As a result, most consumers decide to purchase mango from competitor nations. Key factors that influence mango purchasing behavior, among consumers, are comprised of production source, price, palatability, and external appearance etc. To address the above problems, it's vital to study the production cost structure, including the cold chain management approach along the supply chain, from upstream activities to downstream, and all other costs relevant to the distribution value of Thai mango (such as oil prices, fertilizer and chemical prices, interest fees, state policy, and shelf and storage life). Research has revealed that the bulk of production costs are incurred at the factory and exporter as there are numerous activities that add value to the mangoes at many levels. Activities that incur the highest proportion of costs include transport and mobility of the produce and output processing. At present, domestic freight systems lack efficient management and state policies are not beneficial to operators and distributors. As a result, operators and relevant parties suffer excessive transportation and production costs which are clearly higher in proportion to other activities.

Keywords: Cost Structure, Cold Chain, Thai Mango, Supply Chain, Cost Assessment

INTRODUCTION

At present, mango is a fruit with considerably high export volume both for premium markets with high purchasing power that require high quality mango (Japan, Germany, United Arab Emirates, and South Korea) as well as markets with low purchasing power that require

medium quality mango (Vietnam, Malaysia, and China) that comprise 78 percent of total export value (Bureau of Agricultural Economic Research, 2012). Currently, overseas markets have high demand for mango consumption as evident from market share data and Thai mango export rankings. Consumers in Japan, South Korea, and China markets tend to base their purchasing decision on production source (85.6%), price (59.4%), palatability and product appearance (37.6%) (Bose and Gething, 2011). Thailand has a mere 17.73% market share and is ranked third, among mango exporters, behind Mexico (38.27%) and The Philippines (21.97%) (Department of Export Promotion, Tokyo, 2013) since mango exported from Thailand suffers from a wide range of problems (National Food Institute, 2013) concerning output consistency, production data traceability, output ripeness consistency, cost ratio management in each of the activities, and monitor and control of residue etc. As a result, mango from Thailand is potentially less competitive than competitors as the harvesting period (March – May) is not aligned with the period when consumers have the highest demand for mango (June – August); additionally, Thai mango is overly sweet in taste and commands a higher distribution price than other countries (Thailand: 100 Baht/pc., Mexico: 67 Baht/pc., The Philippines: 34 Baht/pc.) etc. The reason why Thai mango is priced higher than competitors is because agriculturalists and state agencies lack awareness, an efficient calculation model for cost effectiveness from upstream to downstream (Sunida, 2011), and capability to apply data obtained in planning and implementation of activities from sourcing of seed, fertilizer, and pesticides; moreover insufficient planning for harvest and distribution of the produce fails to ensure maximum efficiency.

Therefore, a study into the cost structure model in the entire cold chain along the supply chain for Thai mango necessitates a cost structure assessment of cold chain along the supply chain for Thai Mango to identify the cost structure starting from the process of seed sourcing, cultivation, crop care, harvesting, distribution, and sale to consumers. Taking into account the variables that play a role in determining the costs of activities relevant to cultivation, harvesting, crop care, distribution of produce, and other activities relevant to the cold chain along the supply chain of Thai mango, such as oil and fuel costs, fertilizer and chemical costs, produce distribution costs, and shelf and storage life, that impact the costs of product transportation and warehousing, enables potential changes to the management costs along the supply chain of Thai mango.

LITERATURE REVIEWS

Cold Chain Management for Thai Mango
Cold chain management of Thai fruit is both extremely complex and complicated with many limitations inherent within its relevant factors including time-related, environmental and imminent physical and physiological changes to fresh fruit, that alters its quality throughout the storage life (Bourlakis and Weighman, 2001; Olsson, 2004; Trienekens et al., 2012) whereby loss of temperature control in each activity poses a direct impact to quality levels of the fresh fruit by the time the products are ready for delivery to customer groups (SARDI,

2006). As a result, operators and relevant agencies must develop and improve the production, logistics, and storage processes by increasing the complexity of the model according to the fruit's changing condition, to ensure that the fruit quality meets customer requirements, by application of fast and efficient supply chain management principles at work (Aung and Chang, 2014). Most fruits are perishable and will rot when stored for lengthy periods without appropriate temperature control along the supply chain. These two factors are matters of utmost importance to Thailand's logistics systems (Montanari, 2008) since a significantly high rate of spoilage occurs during logistics and storage (Ruiz-Garcia and Lunadei, 2010), in particular fresh fruit transported by sea, resulting in massive income losses on behalf of operators.

At present, stage agencies strive to continuously develop and improve the production and quality control model to ensure the quality and safety of fresh fruit. Nevertheless, the success of fresh fruit cold chain management partly relies on the close monitoring and control of temperature levels, to maintain appropriate levels at all times, and the efficient monitoring of chemical residue levels, insects, and plant disease within each stage of production (Ruiz-Garcia and Lunadei, 2010). This will result in a longer storage life for fresh fruit (30 days after harvest) and levels of quality that meet customer requirements.

Control of environmental factors that impact the fruit's biological and physical changes, from the harvesting stage until it reaches consumers' hands, is of utmost importance to extending storage life across each activity within the cold chain management of fresh fruit (Somphop, 2010) as it reduces the fruit's respiration rate (Martin and Ronan, 2000). A decrease in temperature to 10 degrees Celsius reduces the fruit respiration rate by 2 – 3 times and increases storage life by 1.5 – 2 times (Kader, 1992). Furthermore, it slows the bacterial growth rate, dehydration, and ethylene production and, as a result, effectively reduces fruit spoilage (Canet, 1989; Alvarez and Canet, 1998; Sousa et al., 2005). However, past interviews and surveys conducted at production sources reveal cold chain management applied along the entire supply chain at harvesting, temperature control, packaging, logistics, and storage (Aung and Chang, 2013). From past research and interviews with agriculturalists, details of the present situation, including an approach for cold chain management among relevant parties throughout the supply chain for mango, may be summarized as follows.

1) Agriculturalists generally lack sufficient knowledge and understanding of suitable temperature control following harvest, in particular, during a plentiful harvest season when abundant produce flows into the market, agriculturalists are compelled to sell mango at cheap prices because of inability to store the mango and await distribution at a later period. Moreover, most of the produce is at quality levels significantly lower than standards demanded by customers. Therefore, to ensure quality produce and to enable lengthy storage periods, state agencies should encourage agriculturalists to control the volume of yield per panicle at suitable levels, not exceeding 2 – 3 mangoes per panicle, and to use

clean apparatus for harvesting, performed primarily by hand, using scissors, with temperature levels controlled during harvest (<25 $^{\circ}$C). The produce must not be stacked higher than 3 – 4 levels. At harvest, the produce must be aged 105 – 113 days following blossom (80% ripeness) and transported for quality sorting and distribution at the soonest to maintain quality of the produce and extend shelf life to the maximum.

2) Agriculturalist Groups / Members of Agriculture Cooperatives are groups generally formed to facilitate agricultural cooperation and marketing among agriculturalists within the same locality and to disseminate important data and information among members, including a knowledge base and modern cultivation methods and techniques; however, these groups still lack sufficient knowledge and techniques concerning efficient temperature control during activity implementation and mango storage. Therefore, state agencies should provide knowledge and organize activities to promote temperature control in the storage of produce including cold storage systems, ventilated packaging, and temperature control techniques between activities etc. This should include techniques and methods of logistics to ensure fast transport of goods, management of produce at each phase, and establishment of a sorting and storage center that maintains suitable temperature levels to increase the competitive edge among members.

3) Gatherers have the duty to gather produce from agriculturalists and perform sorting according to size and quality before distributing to suppliers, retailers, and exporters both domestically and overseas. Generally, gatherers lack appropriate temperature control during storage, tend to use poorly ventilated packaging and delayed and disorganized logistics. As a result, the shelf life for mango is shortened while the loss ratio during delivery is increased. However, state agencies should encourage gatherers to develop their cold chain and product storage systems, to speed up logistics systems, with appropriate temperature controls, and using properly ventilated packaging, to extend the storage life of products, and to reduce gathering costs.

4) Suppliers / Retailers / Wholesalers generally buy the goods from agriculturalists, gatherers, and exporters before further distribution to domestic and overseas consumer groups. Overall, these groups apply cold chain management in a similar model to domestic gatherers and are faced with identical problems and opportunities for development.

5) Production and Processing Plants / Exporters have a duty to gather produce from agriculturalists and gatherers before sorting size and quality, cleaning, steaming, packaging, and storage, after which the goods are distributed to domestic and overseas suppliers. Overall, the following cold chain management applies.

- Generally, there is no temperature control in place during transportation of produce to plant but there are quality control measures implemented throughout the transport process. The transport of goods is performed solely at employees' convenience. Therefore, operators should improve the product transportation model to maintain suitable temperature levels i.e. remodeling the freight systems to transport goods at dusk or night to ensure prompt delivery for morning processing and to avoid excessive contact with heat meanwhile.

- During processing operations at the plant, there are typically no temperature controls while sorting, trimming, and steaming; but temperature control is present after the mango is moved to the plant's cold storage facility to await further transport to customer groups and consumers. Therefore, operators should add temperature controls at each processing phase to maximize shelf life. Nonetheless, processing plants tend to use appropriate packaging methods.

- Temperature controls are generally present while transport of produce from plant to distribution center is underway, after which the goods are further dispatched to overseas markets by sea and air freight. If transported by sea, the cargo is stored in temperature-controlled containers at all times without a definite lead time for delivery. If transported by air, no temperature controls are present throughout the journey but there is a definite lead time for delivery and high costs incurred. Product packaging during transport to the distribution centers is considered suitable. However, operators should sufficiently develop production methods and raw materials management for sea freight to reduce logistics costs. Moreover, the state sector should reduce the documentation procedures to increase speed and convenience in product delivery.

6) State Agencies have a duty to develop the supply chain systems of Thai fruit, research and develop quality production methods, promote value added to agriculturalists, and enhance export efficiency of Thai fruit to overseas markets, including development and improvement to increase efficiency of cold chain management systems for fruit. At present, agencies give priority to the development of cold chain systems only within a limited group of operators and exporters, but not widespread among agriculturalists as needed. Therefore, efforts should be expanded to increasingly reach agriculturalists and gatherers to ensure cold chain management along the entire supply chain with maximum storage life and efficiency for mango.

The above problems and cold chain management approach for mango summarizes the details concerning cold chain management of mango starting from the farm, processing plant, product distribution, suppliers, and logistics systems illustrated in Figure 1 as follows.
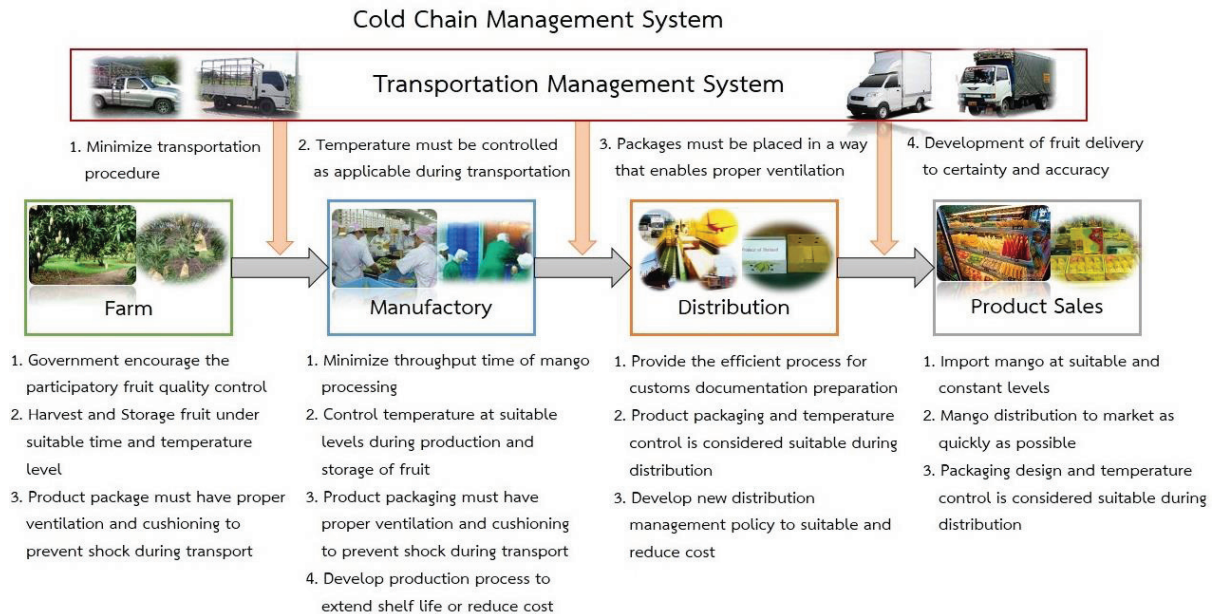
Figure 1: Cold Chain Management Model for Mango
Source: Interviews conducted with agriculturalists and operators, 2013.

Cost Structure

There are various calculation methods available for cost structure. Research by Sirima (2002) states that production costs are comprised of raw materials, labor, and production overhead. The Bureau of Agricultural Economic Research (2009) provides a summary of factors relevant to the calculation of fruit production costs as raw materials, labor, packaging, logistics, management, and other relevant expenses. Additionally, Porntipa (Ongkunaruk P., 2011) summarizes the various components in fruit production cost calculation as fixed costs, variable costs, and mixed costs. Nevertheless, this calculation of production costs for mango will consider costs that arise at the work operations of each activity in mango production whereby the cost calculation system considered for each activity has been developed and improved to suit actual conditions. Moreover, the data obtained will be applied to enhance efficiency of the production process. Costs will include actual overhead costs incurred in each production activity and each various activity will be specified including its relevance to the entire production process, resource analysis, and activity drivers, to comprehensively and accurately identify each type of resource spent at each given activity. Calculation systems for each activity are comprised of production costs, trade costs, financial costs, and tax costs (Anurak, 2005) etc. Production costs account for all costs related to mango production, from the cultivation and soil preparation stages, to crop care, harvesting, collecting, sorting, logistics, processing, and product distribution and sale etc. Trade costs account for all costs related to trade promotion, marketing, and all export management activities i.e. contact and coordination, product guarantee, central labor costs etc. Financial costs account for costs incurred by obtaining finance or conducting financial management on behalf of the operator

i.e. interest and various fees etc. Finally, tax costs account for costs that arise from income losses on behalf of the operator who must allocate a portion to the government in accordance with laws and regulations in effect but excludes obtaining loans, or product sales, by the operator. Although, it's a difficult task for operators and agriculturalists to manage costs at a minimum, it's possible to keep costs at an acceptable level. However, the following illustration summarizes the various cost structure components in mango cultivation for export and domestic distribution is shown in figure 2
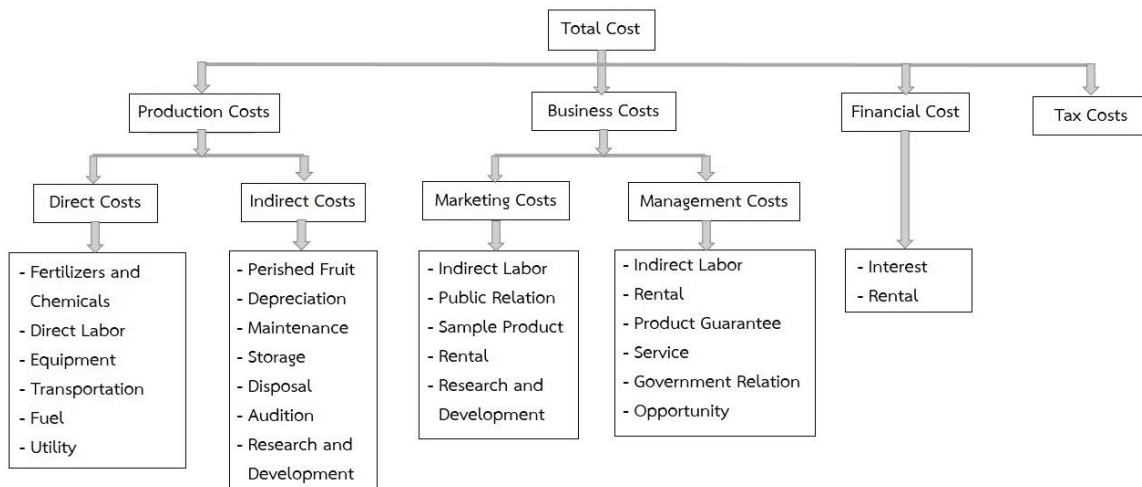
Figure 2: The entire cost structure of the fruit supply chain
Source: Ongkunaruk and Piyakarn, 2011.

THE RESEARCH METHODOLOGY

The research was carried out as a literary research. The research was based on the following
1. Study, design, and develop the questionnaire for agriculturalist groups and operators in alignment with the cost structure of cold chain system along the supply chain for mango.
2. Gather data by means of interviews conducted with agriculturalists, operators and state agencies in Thailand's central, northeastern, and eastern regions (Pitsanulok, Phichit, Nakorn Ratchasima and Chachoengsao).
3. Summarize relevant details concerning the cold chain system in each activity of mango production.
4. Analyze relevant costs in each activity of mango production to determine the proportion of costs incurred. Details appear in Table 1.
5. Assess the production costs in proportion to each activity including the supply chain system of agriculturalists, operators, and relevant agencies.

6. Propose improvements to the modus operandi and for ideal cost management to enable efficient competitiveness with competitor nations.

Table 1 Mango Production Activities and Relevant Expenses

Activity	Details of Expenses Incurred
1. Cultivation and soil preparation	Expenses related to purchasing and sourcing of fertilizers and other necessary equipment, including logistics, wages, data research, and opportunity costs of interest on bank deposits.
2. Crop care	Expenses related to the purchase of fertilizers and pesticides including logistics, wages, communications, and opportunity costs of interest on bank deposits and state policy.
3. Harvesting	Expenses related to the purchase of equipment for harvesting, transport of produce, labor, communications, and opportunity costs of interest on bank deposits and state policy.
4. Gathering	Expenses related to the purchase and sourcing of necessary equipment, transport, wages, rental, and opportunity costs incurred by losses.
5. Sorting	Expenses related to the sourcing of labor, equipment, wages, energy fees, food and drink, communications, rental, and opportunity costs incurred by losses.
6. Transport of goods	Expenses related to sourcing equipment, energy fees, food and drink, logistics, communications, opportunity costs, product management and documentation, depreciation, and various other relevant expenses.
7. Processing plant	Expenses related to sourcing equipment and raw materials, wages, energy fees, interest, depreciation, maintenance of machinery and equipment, opportunity costs incurred by losses, waste disposal, communications, product management and documentation, various other expenses, and rental of land and building.
8. Product distribution	Opportunity costs incurred by losses, communications, product management and documentation, transport of goods, and other relevant expenses.
9. Product sales	Marketing and PR costs, product management and documentation, interest and taxes, building rental, opportunity costs incurred by losses, and transport of goods.

Source: Chonlachart Piyakarn, 2011 and interviews with agriculturalists and operators.

SUMMARY

Present cost structure analysis by means of calculating costs incurred at each activity along the supply chain, together with mutual cold chain management implementation, reveals that activities related to mango production for export to overseas markets are divided into the

following nine groups: cultivation and soil preparation activities, crop care activities, harvesting activities, gathering activities, sorting activities, logistics activities, processing activities, distribution activities, etc. Each activity involves six various individual or agency groups as follows: agriculturalists, raw materials suppliers, gatherers, plants / exporters, distributors, and state agencies etc. Calculation of costs, in each relevant activity along the supply chain system for mango, is performed by taking into account all proportionate costs throughout the supply chain and within each activity. This enables one to identify the details of expenses incurred during cultivation, crop care, harvesting, and transport activities, of fresh mango, to the product distribution point, for each plot of land, according to area, yield, and arable land, as divided proportionately, according to relevant parties along the supply chain system, and applicable to all types of fresh fruit.

At present, Thailand's eastern region has a great proportion of agriculturalists, operators, state agencies, and relevant parties. As a result, random interviewing of agriculturalists, operators, and relevant parties, which are the sample groups in this research, must include random samples with wide range of diversity and should cover all demographic groups. The researcher has interviewed 30 persons of sample groups, whereby 15 have given complete information, of which said data obtained has 95% credibility. As a result, the data concerning expenses incurred, at each production activity along the supply chain, contains comprehensive and precise details. The activities' details calculated into the cost structure of mango, starting from cultivation activities until distribution activities, entirely reveal proportions of costs absorbed by agriculturalists, gatherers, distributors / retailers / wholesalers, processing plants / exporters, and state agencies, altogether related to work operations in areas of cultivation, sorting, processing, and transportation of mangoes in Thailand's eastern region. The cost structure along the supply chain for mango is summarized in the following illustration Figure 3.

Cost Structure in the Mango Supply Chain
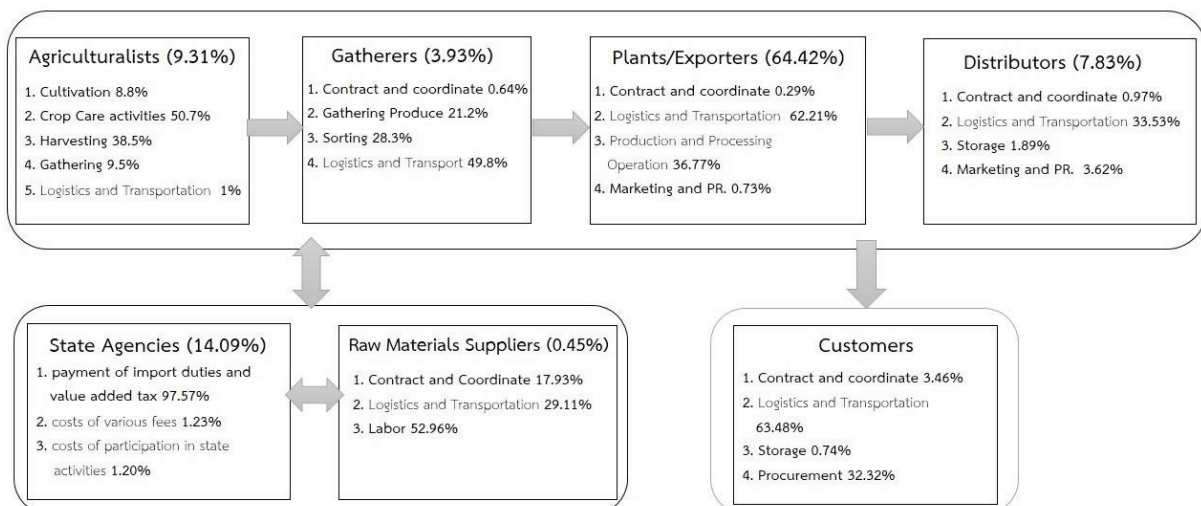
Figure 3: Cost Structure of Relevant Parties in the Mango Supply Chain

As Figure 3 illustrates, the bulk of mango production costs are incurred at Plants / Exporters (64.42%), followed by State Agencies (14.09%), Agriculturalists (9.31%), and Distributors (7.83%) respectively. This is because the mango processing operations of Plants / Exporters involve activities that require many levels of support to enable the various work operations. As a result, the operator's management fails to obtain data of actual costs per unit in each activity that takes place. The expenses incurred by each activity do not directly appear in the manufacturing costs but are considered costs of general management, personnel development, general services, and IT services. Instead, operators consider these as support activities in which profits are not necessarily derived. Consequently, cost calculation of production activities within the enterprise fails to reflect actual production costs incurred and potential profits, to be gained from product sales, are reduced. However, the main costs incurred at Plants / Exporters include Logistics and Transport of Goods (62.21%), this includes both external logistics and internal transport within the plant premises since oil prices are high and raw materials sources are located far from the plant, second place is the Mango Production and Processing Operation (36.77%), which incurs costs from fruit trimming, cleaning, sorting, steaming, storage, and packaging activities etc. Whereas costs incurred by State Agencies generally arise at payment of import duties and value added tax (97.57%), second place is costs of various fees (1.23%) and costs of participation in state activities (1.20%). Furthermore, the supply chain of mango production for export primarily includes Agriculturalists / Manufacturers (9.31%), mostly in crop care activities (50.7%), harvesting (38.5%), gathering (9.5%), and cultivation (8.8%) etc.

Nevertheless, the cost structure details within each activity along the mango production supply chain reveal that actual production costs realized by agriculturalists are 15.21 Baht / Kilogram. After management costs of gatherers are included, the costs reach 24.27 Baht / Kilogram. Once the processing and packaging operations are completed, the costs reach 107.65 Baht / Kilogram. By the time the mango is distributed to consumers, the total costs are 132.14 Baht / Kilogram. Details of the cost structure across various relevant activities are illustrated below in Figure 4.
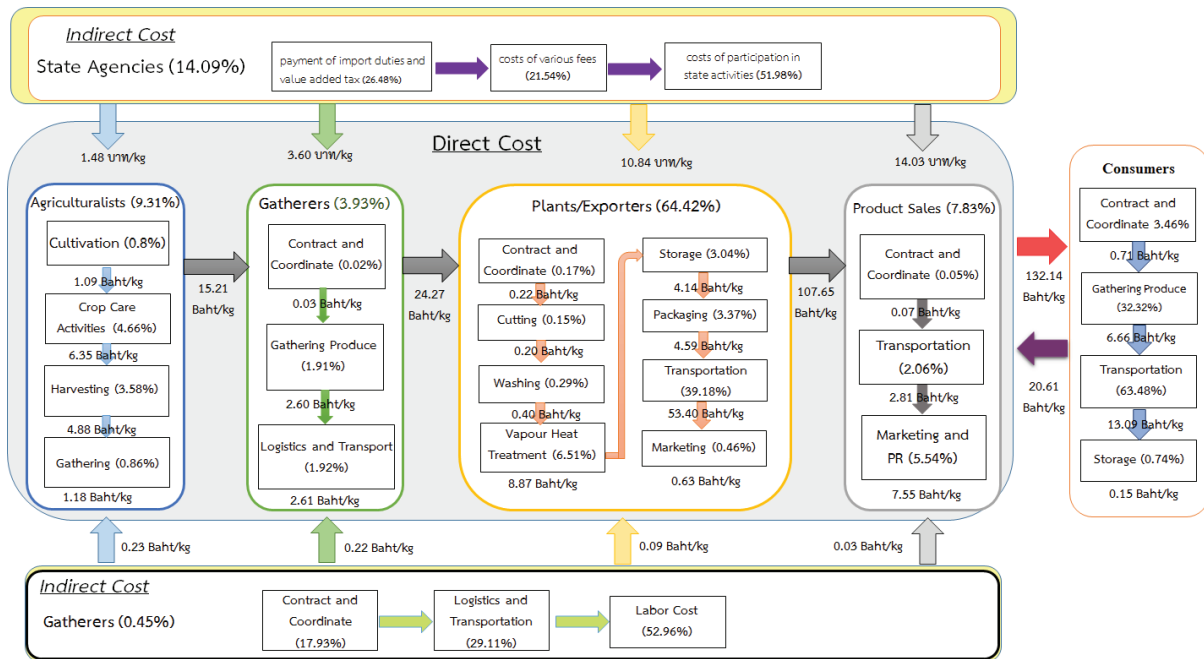
Figure 4: Cost Structure along the Mango Production and Processing Supply Chain.
Source: Interviews with agriculturalists and operators, 2013.

The cost structural relationship of fresh fruit production for export, from all relevant groups, in the fresh fruit supply chain of Thailand reveals that logistics costs for transportation of products and raw materials are the highest. This is caused by Thailand's inefficient product logistics systems, production management, and domestic and overseas freight, including state policies that fail to accommodate agriculturalists, gatherers, operators, and distributors both domestic and overseas. Consequently, agriculturalists and relevant parties must bear the aforementioned costs at a significantly higher rate than other areas of production costs. This problem partly originates from fundamental factors within the country comprised of formalities at customs, basic infrastructure, the international freight model, logistics capabilities, product monitoring and tracking, punctuality, and inefficient domestic freight systems etc. These various factors put Thailand at a strong disadvantage with inefficient capabilities when compared with competitor nations.

REFERENCES

1. Alvarez, M.D. and W. Canet. (1998). Effect of temperature fluctuations during frozen storage on the quality of potato tissue. **Zeitschrift Fur Lebensmittel-Untersuchung Und-Forschung A-Food Research And Technology** 206, 52–57.

2. Aung, M.M., Y.S. Chang and W.R. Kim. (2012). Quality monitoring and dynamic pricing in cold chain management. **Engineering and Technology** 62, 435-439.

3. Bogataj, M., L. Bogataj and R. Vodopivec. (2005). Stability of perishable goods in cold logistic chains. **Int. J. Production Economics** 8, 345–356.

4. Bose, N. and K. Gething. (2011). Japan Mango Consumer. **Trade and Investment Queensland Australia**. Retrieved July 30, 2013 form www.export.qld.gov.au/wp.../2013/.../Japan-mango-consumer-15-8-2011.pdf

5. Bourlakis, M.A., and & P. W.H. Weighman. (2001).**Food Supply Chain Management**. Blackwell Publishing. pp. 179-198.

6. Bureau of Agricultural Economic Research. (2010). **Logistics and Supply Chain Management for Thai Fruit in East**. Bangkok. Aug, 19

7. Bureau of Agricultural Economic Research. (2011). **Annual Agricultural Statistics of Thailand 2011.** Information Technology Center, Department of Agricultural Extension. Bangkok.

8. Bureau of Agricultural Economic Research. (2012). **Annual Agricultural Statistics of Thailand 2012.** Information Technology Center, Department of Agricultural Extension. Bangkok.

9. Canet, W. (1989). Quality and stability of frozen vegetables. **Developments in Food Preservation**. Elsevier, London, pp. 1–50.

10. Department of Export Promotion. (2011). **Fruit Market in Japan**. [Online] : http://www.depthai.go.th/DEP/DOC/54/54000984.pdf . [Accessed 12/9/2012]

11. James S.J. and James C. (2010). The food cold-chain and climate change. **Food Research International.** Vol. 43, 1944-1956.

12. Kader, A.A. (1992). **Postharvest Technology of Horticultural Crops**. University of California (no.): 240.

13. Kuo, J.C. and M.C. Chen. (2010). Developing an advanced multi-temperature joint distribution system for the food cold chain. **Food Control** 21, 559-566.

14. Martin, G. and Ronan, G. (2000). Managing the cold chain for quality and safety. **Flair-Flow Europe Technical Manual 378A/00**, [Online]. From: http://www.teagasc.ie/ashtown/research/preparedfoods/managing_the_cold_chain.pdf [Accessed 15/9/2012]

15. Medina, J.D.L.C. and H.S. Garcia. (2002). **Mango: Post-Harvest Operation. Instituto Tecnologico de Veracruz**. Food and Agriculture Organization of the United Nations. 37-48.

16. Montanari, R. (2008). Cold chain tracking: a managerial perspective. **Trends in Food Science & Technology**, 19(8), 425–431.

17. National Food Institute. (2013). **Supply Chain Management Development Design with Cold Chain Management to Export for Thai Mango and Thai Mangosteen**. Ministry of Industry. Bangkok.

18. Olsson, A. (2004).Temperature controlled supply chains call for improved knowledge and shared responsibility. **Conference Proceedings NOFOMA 2004**, Linköping, pp.569-82. Retrieved form http://lup.lub.lu.se/luur/download?func=downloadFile&recordOId=539001&fileOId=625938

19. Ongkunaruk P. and C. Piyakarn. (2011). Logistics Cost Structure for Mangoteen Farmers in Thailand. **Systems Engineering Procedia** 2, 40-48.

20. Ruiz-Garcia, L. and L. Lunadei. (2010). **Monitoring Cold Chain Logistics by Means of RFID**. Substainable Radio Frequency Identification Solutions, Croatia, Intech, 37-50.

21. SARDI. (2006). Maintaining the cold chain: air freight of perishables. **South Australian Research and Development Institute [Online].** From:
http://www.australianairfreight.com/ vac/pdfs/airfreight_perish.pdf [Accessed 2/10/2012]

22. Sousa, M.B., W. Canet, M.D. Alvarez and M.E. Tortosa. (2005). The effect of the pretreatments and the long and short-term frozen storage on the quality of raspberry (cv. Heritage). **European Food Research and Technology** 221, 132–144.

23. Somphop, Y. (2010). **Cool Chain Management for Fresh Produce.** Food Technology, Siam University 5 (1): 1-60.

24. Sirima, K. (2002). **Manufacturing Cost System Improvement by Activity Based Costing: Case Study an Educational Toys Factory**. Industrial Management Engineering, King Mongkut's Institute of Technology North Bangkok. Bangkok.

25. Sunida, P. (2011). SMEs Global Biz. **E-journal of Department of Industrial Promotion** 54, Jul – Aug.

26. Trienekens, J.H., P.M. Wognum, A.J.M. Beulens and J.G.A.J. van der Vorst. (2012). Transparency in complex dynamic food supply chains. **Advanced Engineering Informatics** 26(1), 55–65.

THE LATEST ECONOMIC CRISIS (2008-) AND ICT USERS&SPENDINGS

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ABSTRACT

The paper presents the research findings of the most recent (2008-) economic crisis impacts on information and communication technology (ICT) spending. The presented research as well enables the identification of parallels and deviations and the comparison of the impacts on ICT users and world regions. We noted certain characteristics and changes during the latest crisis, which imply the transformation of ICT, as well as the impact of various factors on the information society,

The research findings confirm that during the latest economic crisis, the negative economic impact varied depending on factors such as the sector, type and size of the user, as well as on the economic development of the region. During the latest crisis (2008-2011) we noted the greatest negative impacts on ICT spending in the manufacturing vertical market and among small and mid-sized companies, while a greater negative impact was seen among business users in terms of the type of end users. The least seen overall crisis imapact was on the other hand observed among healthcare and government institiutions and the largest businesses.

Thus, we have demonstrated that the factor of increasing ICT integration in the companies' operations, which allows and requires new trends and adaptation of ICT users in the crisis period, is undoubtedly very important, in addition to economic and technological factors. The research therefore enabled critical evaluation of certain theories, which serve to explain the identified problem, while we were also able to develop an alternative view on the phenomena, in particular on the ICT impacts on the economy, society, etc. and vice versa.

Keywords: information and communication technology (ICT), latest (2008-) economic crisis, ICT spending, ICT markets, ICT users, world regions.

INTRODUCTION

During the latest (2008-) economic crisis, also changes in the ICT field, in the usage of ICT and in the ICT spending of world regions occured. ICT spending, ICT investments, as well as funding of development and innovations in this field decreased. We noted certain characteristics and changes during the latest crisis, which imply the transformation of ICT, as well as the impact of various factors on the information society, which we tried to check using the actual figures to provide explanations for our findings. We focused on the rules, trends and on the response of the users, manufacturers and suppliers of ICT to the changed situation during the latest economic crisis.

We believe that in the time of the latest economic crisis, the negative economic impact on the ICT use varies, depending on factors, such as sector, type and size of the user, as well as the economic development of the region.

We anticipated that a detailed analysis of the data will show deviations regarding the sector, type (private or business) and the size of the user (in terms of the number of employees in the company using ICT). Some sectors are more dependent on the use of ICT than others and therefore they cannot reduce ICT spending during the crisis period as much as others can. In addition, variations in decline of ICT spending in terms of the sector are also a result of: the importance of certain sectors in a certain economy, the development of specific sectors and different origins of the crisis (e.g. the impact of the financial crisis on consumption in the financial sector).

The size and the type of the user are also important in terms of greater deviations that are expected among different groups. Depending on the type of user, we expected a larger effect among private users, since as a result of the increasing unemployment (which usually still decreases, also when the improvement of economic indicators starts appearing) in times of crisis, long-term negative effects on the ICT spending may be shown among them as among the business users.

Considering the size of the user, we expected the greatest drop of ICT spending among the largest companies, because they usually first and most strongly feel the effects of the crisis, while we expected a long-term impact among smaller companies, as they lack free resources for investments as a result of long-term depletion and are usually exposed to the credit crunch for a longer time (due to higher risks they pose to the banks).

Different impact of the crisis on ICT is expected to be well visible even when comparing different regions and individual countries. We assumed that the ICT indicators would show

minor fluctuations in economically developed regions and countries, but greater fluctuations in economically less developed regions or countries. Differences in economic performances between industrialized countries can also be explained by the level of ICT investment, the level of ICT use and the competitiveness of the information society (European Commission, 2005). Differences in the rate of IT growth in crisis periods in individual countries are thus dependent on the differences in the levels of IT development (Daveri, 2000).

Investments in ICT are reflected in a variety of impacts. However, both, positive and negative impacts should be emphasized. In times of the economic growth and the economic crisis the costs of the purchase and maintenance of ICT vary. I.e. when comparing the ICT market with the commodity market, we note that a short term price reductions or price reductions limited to the crisis period are not possible, due to the fast development of ICT. Moreover, the prices of ICT products, which were decreased due to the crisis, can be increased after the crisis with great difficultly, as due to the technological progress there are already newer and more powerful products available. On the contrary, raw materials prices begin to rise when the economic situation starts to improve (IMF, 2010). The reason for this must be sought in the fact that the ICT development is very fast (Moore, 2007; Zemanek, 2006) and continues also in times of crisis. In line with the reduced investments in other areas, also the development of ICT slows down during the crisis in some areas, while it increases especially in those areas that allow a reduction of expenditures and increase of competitive advantages, which is significantly more interesting for the users in the times of the crisis. Nevertheless, the specific nature of ICT investments is reflected in their long-term or strategic planning, as well as in the urgency of these investments, as in the modern societies the use of ICT has become one of the norms and requirements (social, economic, cultural and legislative).

In addition to the negative impact, the latest economic crisis also had positive (especially from ICT user's point of view) impact on the ICT use. It led to further price reductions of ICT equipment and services (as well as of many other prices for products, materials and services) and stipulated the increase in the number of various other attractive offers, stimulating consumption. At the same time the relationship between providers and users has changed considerably (May, 2008).

The relationship between the impacts of ICT and on ICT is very difficult or even impossible to measure, and therefore this research focused on measurable ICT indicators, although we also used qualitative research methods for the explanation of certain findings. Therefore we also considered other ICT aspects for the interpretation of certain results of the research (economic, social, political ...), which are presented in the next section. The methodology chapter is followed by research findings that provide answers to research questions, while in the conclusion we presented our alternative view on the theoretical basis.

Proceedings of 2014 International Conference on
Technology Innovation and Industrial Management
28th-30th May 2014, Seoul, South Korea

ICT IN THEORY

ICT is primarily understood as a socio-technological system for information processing, the use of which causes specific social changes, in addition to its direct technological impact (Kling *et al.*, 2005).

Under the environmental influences, ICT affects the society, as well as the economy, policy, culture, globalization, etc. In the modern sense of the word, ICT spreads over business and administrative processes from the beginning of 70s, when the widespread use of computers began. The introduction of internet in the '80s further increased the role of ICT. In the 90s, ICT reached a significant peak, when (with the help of communication technology) a powerful tool for business and general development was created through the merge of the personal computer and web technology (Carr, 2006).

ICTs also facilitate and promote the emergence of global society, global communication, global market, the globalization of capital, the new global division of labor (Vreg, 2001) and contribute significantly to economic growth, productivity, efficiency and performance at the macro-and microeconomic level (Stare and Bučar, 2005b). At the same time, the impact of ICT increasingly penetrates into the economic, political and social sphere (Berce *et al.*, 2008) and vice versa, given that ICTs are increasingly imbued with social, economic, cultural and other aspects.

Although ICTs are actually a technological achievement, their social implications go far beyond mere technological functionality (Stare and Bučar, 2005). Until recently, discussions about the impact of ICT focused primarily on issues of economic growth and productivity. But it is becoming increasingly apparent that the effect of ICT is much broader and covers all spheres of economic and social life. Thus, the expansion of the ICT use has a strong impact on patterns of life, work and communication (Carr, 2006), as ICTs became part of every individual life since the explosive growth of the ICT use in the nineties (Lukšič, 2003).

Already in the 60s and in the 70s of the past century some prominent sociologists gave a new perspective on modern society, especially in the light of increasingly rapid technological change and related impacts on society; we started to talk about the post-industrial society. In parallel with the concept of post-industrial society, also the concept of the information society gradually evolved. Castells' study "The Information Age" indicates the direction, on which research the theory of modern society focused.

In the scientific literature various concepts of information society are used, for example: technocratic era (Brzezinski, 1970), post-industrial society (Bell, 1976), the information

economy (Porat, 1977), the economics of information (Machlup, 1984), digital capitalism (Schiller, 1984), information capitalism (Morris-Suzuki, 1986), the digital economy (Negroponte, 1995), post-modern society (Lyon, 1995), the knowledge economy (Leadbeater, 2000), knowledge society (Drucker, 2003), society of networks (Castells, 2006), information capitalism (Webster, 2006), transnational capitalism of networks (Fuchs, 2008)...

Due to the development and diffusion of ICT, work organization, strategic decision-making, technical operations and other aspects of life in advanced information society significantly changed (Bannister and Remenyi, 2003). Webster (2006) distinguishes between five approaches to the information society: technological, economic, spatial, cultural, and professional. For each of the approaches he recognizes both positive and negative social impacts of the information society. Many authors also claim (eg. May, 2002) that we are in a new era ruled by a new paradigm, where the social and economic relations are no longer primarily organized on the basis of material goods and now everything is (or will soon be) organized on the basis of information and knowledge.

However, since new technology is in use within the existing political and economic framework, it increases the impact of existing stakeholders and therefore the existing social inequalities retained or even increased, critics claim. Like all technology, IT has also been selected and designed in accordance with the interests and determinants of society and politics (Kumar, 2005). Beniger (1986) also argues that technological and economic origins of the information society lead to a revolution of control, which is available to countries, companies and individuals. The information society is therefore a global phenomenon with technological, economic, historical, cultural and political dimensions, which change over time.

Harper and Leicht (2007) also note that researchers of this field do not yet have sufficient understanding of the basics for concrete predictions regarding the social implications of ubiquitous innovation. This is particularly interesting in view of the understanding and interpretation of the ICT role, especially in economic crisis circumstances.

RESEARCH METHODOLOGY

This study is methodologically divided into quantitative and qualitative parts or three interconnected phases of the research process. The first phase includes a systematic analysis of sources and literature review, which enabled the theoretical basis and data for empirical analysis.

Based on the defined goals of our study, we compared in particular the crisis impacts on ICT over time with the analysis of the available data . The basis for the analysis were different macroeconomic data and quantitative ICT indicators - variables that show ICT spending, which

allowed an in-depth evaluation of existing literature and the research of various dimensions of impacts, as well as the in-depth research.

For empirical analysis we needed to address ICT primarily as a precise set of individual technologies, and for this purpose we used the ICT definition used by IDC (International Data Corporation), international company founded in 1964, which analyzes ICT spending on global, regional and national levels. We put the consumption indicator in the center of our research (the used levels that exclude the exchange rate fluctuations = constant USD). This is a financial expenditure, which private and business users allocate for the purchase of ICT equipment or of ICT services. ICT consumption therefore has a different meaning than investment to ICT, which includes financial expenditure for the increase of ICT capital value. Placement of the ICT consumption indicator in the focal part of the research seemed to be most reasonable, because it allows a comprehensive and detailed overview of the ICT purchase.

Such consideration also enabled us to analyze the ICT spending by: individual sectors of the economy, the type of the user (business, private) and the size of the user (in terms of the number of employees). Here we noted certain deviations from expectations; of particular interest are variations of these indicators during the last economic crisis, as user groups responded differently. Benchmarking thus presented the core of the study; our main objective was to verify the parallels and deviations and to find new rules in the field of ICT in the time of the last economic crisis. In particular we explored the differences in the ICT spending depending on factors such as sector, user type and size, as well as the economic development of the region or country. To determine different impacts of the latest economic crisis, we thus analyzed ICT spending trends in terms of:

- Individual sectors (government, education, healthcare, manufacturing, finance, telecommunication, trade, business services, transport and utilities);
- User type (business, private) and
- User size (small companies (up to 99 employees), mid-sized companies (100-499 employees), large companies (500-999 employees) and very large companies (over 1000 employees)).

Thus, we were able to observe, which ICT users (depending on the sector, user type and size of the user) reduced the ICT spending in a larger extent and which in a smaller extent during the latest economic crisis.

When collecting the data on the spending we nonetheless encountered certain limitations, since data on the whole ICT spending with regards to user size are not available. This information was available only for certain segments of IT hardware, not for the ICT as a whole.

Thus, because personal computers are the most widely accepted IT hardware technology, we compared the spending for personal computers depending on the user size.

Additionally, we have taken into account the opinions of ICT services providers, ICT users, and also other research analysts, who study this area, which deepened the understanding of the impact factors and the perceived changes in the ICT field. At this point we also involved case studies (ICT investments of certain groups of users) and all this served as a basis for explanations of determined ICT impacts on users, critical assessment of sources and theoretical conceptualizations, and also as a credible explanation of our findings.

RESEARCH FINDINGS

A detailed analysis of ICT spending therefore showed the predicted deviations by different sectors, type (private, business) and the size of the user (in terms of the number of employees), which primarily depends on perception of crisis in individual sectors or type and size of users, and on the integration of ICT in the operations of these user groups. For example, some industries depend more on ICT use than others, as well as business users more than private, while also greater deviations can be observed among different sizes of the users. We also anticipated that the different drop of ICT spending in relation to the sector is also affected by: the importance of certain sectors in each economy, the development of specific sectors, as well as different origins of the crisis (eg. financial crisis, which turns into the economic crisis).

The analysis of the ICT spending during the latest economic crisis among individual sectors shows that in 2009, the decline of ICT spending worldwide was mostly caused by the reduced ICT consumption in production and in trade (Figure 1). On the other hand, ICT spending decreased in the smallest extent in healthcare and in government sector, but the health institutions contributed only 2.0% to total ICT spending in that year, while the government sector contributed 10.4%.
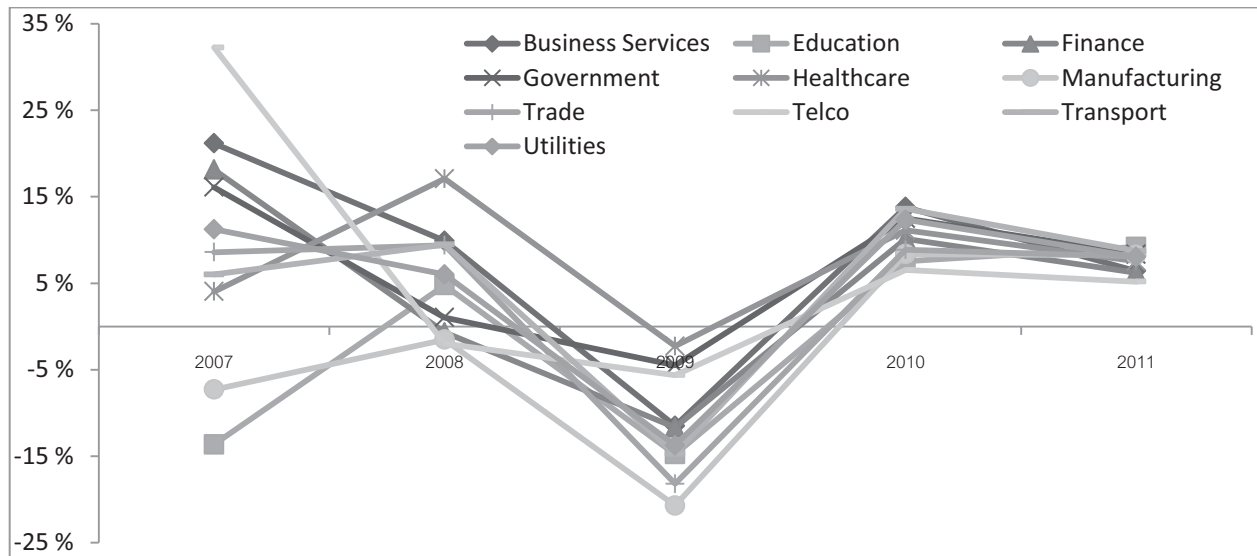
Figure 1: Worldwide ICT spending percent change by sectors (the rate applied excludes exchange rates fluctuations = constant USD)
Source: IDC, 2011a.

The most negative impact of the latest economic crisis was seen in the manufacturing companies (the same was noted in the EU). On the other hand, worldwide ICT spending increased the most in healthcare during the latest economic crisis.
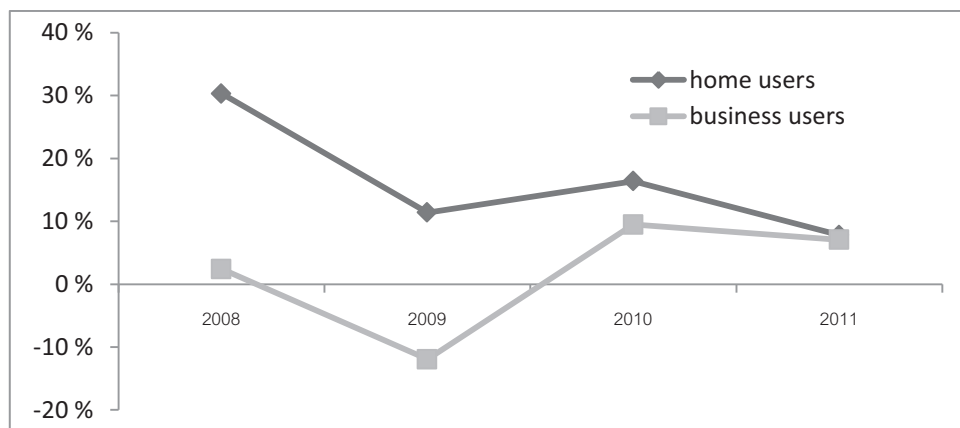
Figure 2: Worldwide ICT spending movement by user type (constant USD)
Source: IDC, 2011a.

Comparative analysis of ICT spending by the type of the user in the time of the last crisis has further revealed that (Figure 2) ICT spending among private users worldwide has not

decreased during the analysed period of the latest crisis, although among private users the growth gradually decreased. The reason for this is in the delayed impact of the crisis on private consumption (gradual increase in the number of unemployed, gradual decrease in incomes ...), as well as in predicted lower ICT use rate among private users.
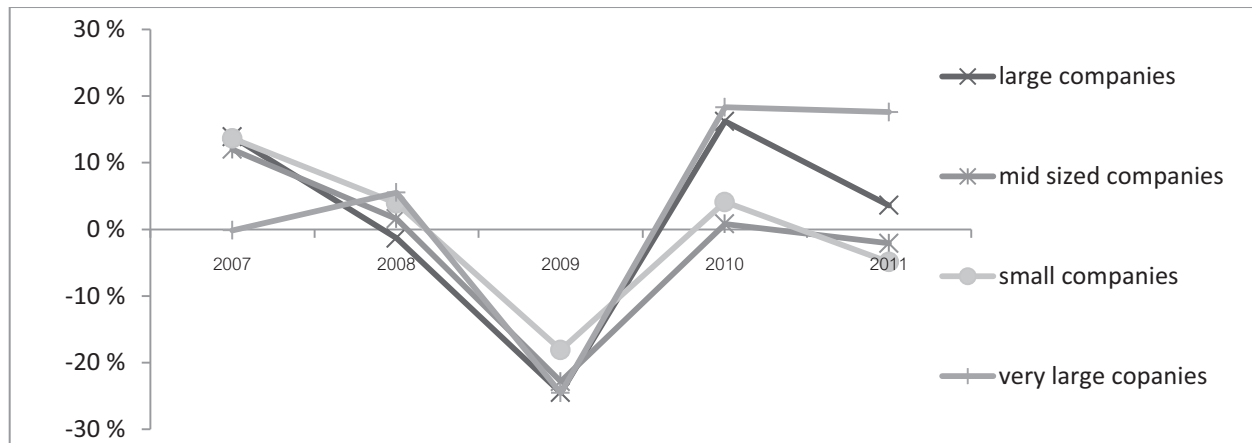
Figure 3: Worldwide PCs spending percent change by size of the user (constant USD)
Source: IDC, 2011b.

Figure 3 explains that the reduced spending on personal computers (PCs) among large and very large companies contributed most to the decline of worldwide spending on personal computers (PCs) in 2009 (the same was noted in the EU). Regarding the number of PCs sold in 2009, the leading user size group were small companies with 51.8 % worldwide (55.9 % in the EU).

In 2010, growth was recorded in the purchase of personal computers in all size groups, while in 2011 spending decreased most notably among small companies. From 2008 to 2011, the spending for personal computers increased only among very large businesses, while it declined in the largest extent among medium-sized and small companies, as those are usually exposed to the credit crunch for a longer period and are usually without their own resources for investments due to the long-term depletion.

On the other hand, the global GDP changes show that the decline was only noted in 2008 (-0.7% in constant prices), which indicates that the crisis impact on the ICT was delayed. ICT spending thus declined only in 2009 (i.e. 1.4%) during the analysed period of the latest crisis.
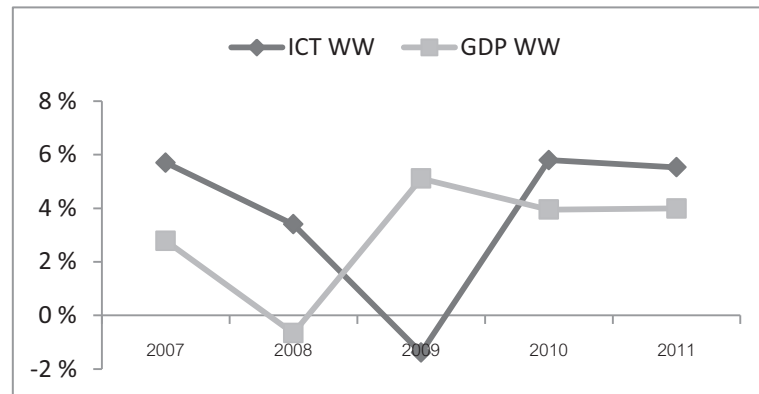
Figure 4: Worldwide ICT spending and GDP from 2007 until 2011 (constant USD/prices)
Source: IDC, 2012; WEO, 2011.

We also analysed ICT indicators at the level of individual regions (Western Europe, Central and Eastern Europe, North America, Latin America, Asia and Pacific, Middle East and Africa). Different crisis impact on ICT is namely very clearly seen when compared to different economic development rate of individual countries and regions, as ICT indicators record lower amplitudes in the economically more developed regions and higher amplitudes in economically less developed countries or regions (Figure 5). In 2009 North America ICT spending thus contributed 28.5% to the global ICT spending, Western Europe 25.0%, Asia and the Pacific 27.7%, Latin America 8.0%, Eastern Europe 4.6%, and the Middle East and Africa 6.2% (IDC, 2012).
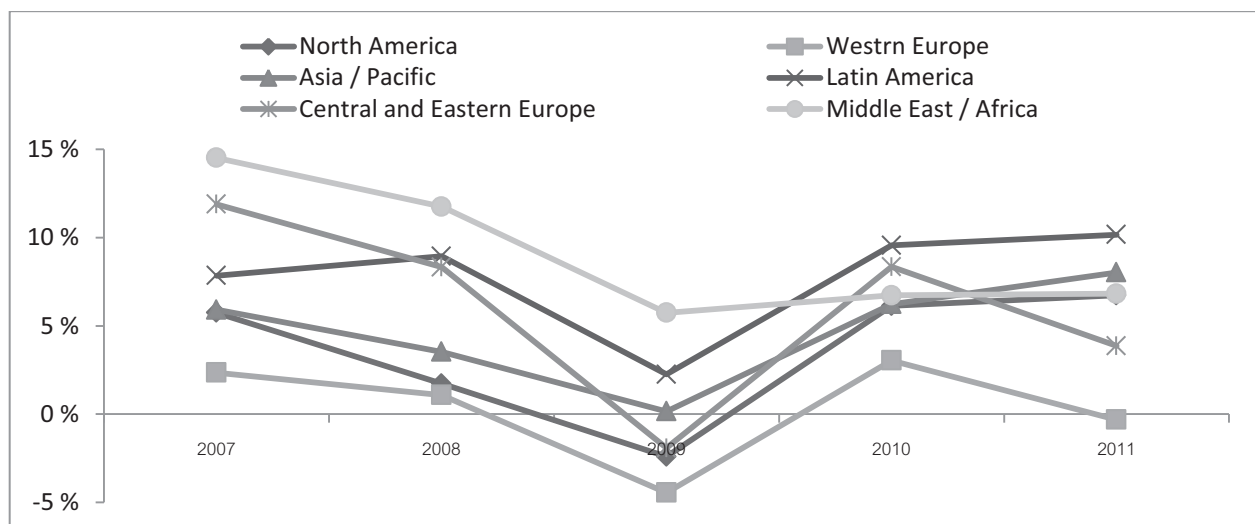
Figure 5: ICT spending percent change by world regions (constant USD)
Source: IDC, 2012; WEO, 2011.

Figure 5 further reveals that the decline of ICT spending in Western Europe (contraction of 4.5%), contributed the most to the worldwide ICT spending decline in 2009. Nonetheless, the ICT spending in 2009 increased in three regions, mostly in the region Middle East and Africa (5.7%). In 2011, the ICT spending decreased only in Western Europe (0.3%).

CONCLUSIONS

The data show that the decline in ICT spending during the latest crisis was also affected by other factors that are present in modern society: the increasing integration of ICT into everyday life (Lukšič, 2003), a major ICT influence on society (Carr, 2006; Bavec *et al.*, 2008), the importance of ICT in the economy and society (Stare and Bučar, 2005b; Berce *et al.*, 2008; Bannister and Remenyi, 2003), etc.. At the same time, in an increasingly developed information society (Castells, 2006; Webster, 2006; Machlup, 1984; Bell, 1976; Drucker, 2003, etc.) ICT investments have become indispensable, as the use of ICT has become one of the norms and requirements (social, economic, cultural and legislative) in modern societies.

The latest economic crisis has also not affected the ICT sector as much as it affected many other sectors, for example construction and production (Eurostat 2009). Also other data (eg. Data from U.S. Census Bureau, 2010) confirm a smaller negative impact of the latest crisis on the ICT demand. They indicate that in 2009 U.S. shipments and new orders of ICT equipment decreased less than shipments and new orders of all other goods (excluding military aircrafts and related spare parts).

As during past economic crises ICTs haven't been so massively used (e.g. mobile telephony and broadband internet), they were also not subject to the impact of the crisis in such a great extent, as they were since the beginning of the latest crisis (International Communication Union, 2009). Thus, we have demonstrated that the factor of increasing ICT integration in the companies' operations, which allows and requires new trends and adaptation of ICT users in the crisis period, is undoubtedly very important, in addition to economic and technological factors.

However, since the economic crisis has, in addition to other associated risk factors, a direct impact on the decreasing demand for ICT, many experts from the ICT field warn that in times of crisis we should not forget some essential elements of successful business and cut costs everywhere (eg. ICT security costs and human resources decrease in the ICT department). We have to realize that some of the new technologies (virtualization, cloud computing, etc.) cause savings, more rational allocation of expenditures, detailed expenditures control and competitive advantage, if we are willing to accept them. In addition, the crisis requires rationalization,

consolidation and a quest of more relevant and effective solutions that may also lower costs, which further accelerates the transformation of ICT.

At the same time it is clear that it is not possible to predict the impacts of technology on society and vice versa, because the society does not automaticaly accept technological innovation. People are the ones whoform social framework that enables technological development. Therefore, we assume also the technological and economic impact of ICT will gradually decrease, while the social, cultural and other influences will gain importance. We also expect that the impact of the crisis on ICTs will become smaller (in terms of decline and growth of ICT spending), as in more developed regions (North America, Western Europe), the fluctuations of ICT spending during the period of crises are less notable, as in other regions. ICT is namely increasingly becoming an essential part of business and social life in general, which is also demonstrated in our analysis.

Changes that the introduction of ICT brought into the life of every individual, thereforehave many dimensions, both positive and negative. Despite many studies dealing with these dimensions, there are still a lot of opportunities to explore and to present alternative views from different angles, as the impacts of ICT and on ICT are becoming increasingly intertwined and complementary at the same time.

REFERENCES

1. Bannister, F., and Remenyi D. (2003), "The Societal Value of ICT: First Steps Towards an Evaluation Framework", *Electronic Journal of Information Systmes Evaluation*, Vol. 6, No. 2, pp. 197-206.
2. Bell, D. (1976), *The coming of post-industrial society: a venture in in social forecasting*, 2nd ed., Basic Books.
3. Bavec, C., Bučar M., and Stare M. (2003), "An Impact of ICT Assesment of Indicators on National and Companies' Level", *Informatica*, Vol. 27, No.2003, pp. 399–404.
4. Beniger, J. R. (1986), *The control revolution: technological and economic origins of the information society,* Harvard University Press, Cambridge (Mass.); London.
5. Berce, J., Lanfranco S., and Vehovar V. (2008), "eGovernance: information and communication technology, knowlede management and learning organisation culture", *Informatica,* Vol. 32, No. 2, pp. 189-205.
6. Carr, N. (2003), "Why IT Doesn't Matter Anymore", *Harvard Business Review,* Vol. 81, No. 5, pp. 5-12.
7. Castells, M. (2006), *The rise of the network society*, 2nd ed., Blackwell, Malden, Oxford, Carlton.
8. Drucker, P. (2003), *The New Society,* Transaction, Rutgers , New Brunswick.

9. EUROSTAT (2009) "Europe in figures: Eurostat yearbook 2009", available at: http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-CD-09-001/EN/KS-CD-09 -001-EN.PDF (accessed 2 November 2009).

10. Fuchs, C. (2008), *Internet and society: social theory in the information age,* Routledge: Taylor & Francis, New York, London, Abingdon.

11. IDC (2011a), "Worldwide Vertical market ICT spending database", IDC.

12. IDC (2011b), "Worldwide PC tracker"*,* IDC.

13. IDC (2012), "Worldwide Black Book Query Tool, Version 2, 2012", IDC.

14. IMF (2010), "World Economic Outlook Database, April 2010", available at: http://www.imf.org/external/pubs/ft/weo/2010/01/weodata/weorept.aspx (accessed 3 July 2010).

15. INTERNATIONAL COMMUNICATION UNION (2009), "Confronting the Crisis: Its Impact on the ICT Industry", available at: http://www.itu.int/osg/csd/emerging_trends/crisis/ report-low-res.pdf (accessed 26 September 2009).

16. Kling, R., Rosenbaum H., and Sawyer S. (2005), *Understanding and communicating social informatics: a framework for studying and teaching the human contexts of information and communication technologies,* Information Today, Medford.

17. European Commision (2005), "Sporočilo Komisije Svetu, Evropskemu parlamentu, Ekonomsko-socialnemu odbori in Odboru regij "i2010 – Evropska informacijska družba za rast in zaposlovanje"", available at: http://www.mvzt.gov.si/fileadmin/mvzt.gov.si/ pageuploads/doc/dokumenti_informacijska_druzba/i2010.pdf (accessed 4 April 2010).

18. Kumar, K- (2005), *From post-industrial to post-modern society: New theories of the contemporary world,* Oxford, Malden; Blackwell, Carlton.

19. Lukšič, A. (2003), "Digitalna Demokracija. Politologija informacijske dobe", *Teorija in praksa,* Vol. 40, No. 3, pp. 487-499.

20. Leadbeater, C. (2000*), Living on thin air: the new economy.* London: Penguin.

21. Lyon, D. (1995), *Postmodernity*, 2nd ed., Open University Press, Buckingham.

22. Machlup, F. (1984), *The economics of information and human capital*, University Press, Princeton.

23. May, T. A. (2008), "Opinion: The good-news recession and IT", *Computerworld Management*, 7 april.

24. Moore, G. F. (2007), "Progress in Digital Integrated Electronics"*,* IEEE, Reprinted with permission from Technical Digest, *IEEE International Electron Devices Meeting 21, (1975), pp. 11–13*.

25. Morris-Suzuki, T. (1986), "Capitalism in the Computer Age", *New Left Review,* Vol. I/160, November-December 1986.

26. Negroponte, N. (1995), *Being Digital,* Hodder & Stoughton, Rydalmere.

27. OECD (2012), "Quarterly National Accounts: Quarterly Growth Rates of real GDP, change over previous quarter", available at: http://stats.oecd.org/index.aspx?queryid=350 (accessed 12 January 2012).

28. Pohjola, M. (2003), "The Adoption and Diffusion of ICT Across Countries: Patterns and Determinants. The New Economy Handbook",. Academic Press,available at: http://www.hse.fi/NR/rdonlyres/2D646BBF-1B66-4B92-AFE4-F3157B6245D5/0/TheadoptionanddiffusionofICT.pdf (accessed 11 November 2009).

29. Porat, M. (1977), "The information Economy: Definition and Measurement", U.S. Department of Commerce, Office of Telecommunication, available at: http://eric.ed.gov/PDFS/ED142205.pdf (accessed 17 September 2009).

30. Rogers, E. (1995), *Diffusion of innovations*. 4th ed., The Free Press, New York.

31. Rojko, K., Lesjak, D., and Vehovar V. (2011), "Information communication technology spending in (2008-), economic crisis", *Industrial Management & Data Systems*, Vol. 111, No. 3, pp. 391-409.

32. Schiller, H. I. (1984), *Information and the crisis economy*. Ablex publishing corporation , Norwood.

33. Stare, M., and Bučar M. (2005a), "Zakaj obravnavati učinke informacijsko-komunikacijskih tehnologij? " in Stare M., and Bučar M. (Ed.) *Učinki informacijsko-komunikacijskih tehnologij*,Fakulteta za družbene vede, Ljubljana, pp. 13-20.

34. Stare, M. (2005b), "Pomen informacijsko-komunikacijskih tehnologij v Sloveniji", in Stare M., andBučar M. (Ed.) *Učinki informacijsko-komunikacijskih tehnologij,* Fakulteta za družbene vede, Ljubljana, pp. 41-56.

35. Stare, M., Kmet Zupančič R., and Bučar M. (2004), *Slovenia - on the way to the information society*, Institute of Macroeconomic Analysis and Development, Ljubljana.

36. U.S. Census Bureau (2010), "Advance Report on Durable Goods Manufacturers' Shipments, Inventories and Orders, December 2009", available at: http://www.census.gov/manufacturing/m3/historical_data/pressreleases/adv/2009/dec09adv.pdf (4 July 2010).

37. Vreg, F. (2001) "Globalizacija in elektronska demokracija. Politološko-sociološki vidiki razvoja informacijske družbe", *Teorija in praksa,* Vol. 38, No. 1, pp. 5-28.

38. Webster, F. (2006) *Theories of the information society,* 3rd ed., Routledge, London, New York.

39. Zemanek, H. (2006), "Človekova izbira in računalniki", *Organizacija znanja,* Vol. 11, No. 3, pp. 66-70.

MOBILE APPS IN TOURISM:
A NEGLECTED TOURISM RESEARCH AREA?

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ABSTRACT

Purpose: *The development of mobile applications (mobile apps) have fundamentally changed how consumers shop virtually. Without the need of a mobile browser, purchasing using a mobile device (m-devices) is now a button click away. While there are plenty of benefits adopting m-apps, past studies were limited to only a few perspectives. Specifically, studies from the tourism industry and emerging markets have remained unexplored. As the adoption of m-apps can potentially generate large revenues for tourism related organizations, the study remains important. Hence, the research examines on the consumers' intention to adopt m-apps as another mean to purchase tourism related product and services.*

Design/methodology: *The study adapted the unified theory of acceptance and use of technology (UTAUT) model using self-administered questionnaires and 186 valid samples.*

Findings: *Based on the PLS-SEM results, facilitating conditions (FC) and social influences (SI) emerged as the only two significant predictors of behavior intention (BI) to adopt m-apps. Similarly, gender only moderates the relationship between SI and BI.*

Research Implications: *Importantly, the findings not only provide valuable knowledge to scholars but also recommend new innovative approach to practitioners such as hotels, airlines, travel agencies, car rental services and other tourism-related organizations.*
Originality: *The research paper contributes to the emerging literatures on m-apps in tourism.*

Keywords: Mobile Tourism, Mobile Applications, Malaysia, Gender, UTAUT

Classification: Research paper

INTRODUCTION

The functionality of traditional mobile phone over the last decade has been used primarily for calling and text features (Wong et al., 2012). Since the emergence of smart phones and the advancement of wireless data networks e.g., 3G (third generation) and now 4G (fourth generation), this has lead to the development of new software possible. Consumers are now able to access the internet on their mobile devices (m-devices) through a stand-alone software known as mobile applications (m-apps). Purcell, Entner and Henderson (2010, p. 2), defines mobile apps as an "end-user software applications that are designed for a mobile device operating system and which extend the device's capabilities by enabling users to perform particular tasks". M-apps enable consumers to access to a wide variety of resources and services without the need of a web browser (Frizzo-Barket and Chow-White, 2012). Kim, Lim and Sung (2013), pointed out that m-apps can also be adopted as another source of purchasing channel. According to Research and Markets (2012), the revenue from the apps market is predicted to surge to $36.7 billion by 2015. Many organizations have started to adopt m-apps as one of the channels for consumers to shop online in view of the huge market potential. There are several benefits adopting m-apps for shopping when compared to the conventional mobile browser (m-browser). First, m-apps overcome the barrier associated with navigating web sites which are not optimized for mobile usage. Second, the benefits of 'always on', 'always on you', and place flexibility (Frizzo-Barket and Chow-White,2012). Third, m-apps leads to greater level of convenience (Cameron, Gregory and Battaglia, 2012), as consumers can used the software to compare prices, obtain discounts, conduct specialized research on products and services, locate stores, access to timeline information, restaurant, transportation, local activities and share information on social networks (Wang and Wang, 2010; Dholakia, 2012; Management Today, 2013). From the business-oriented approach, m-apps lead to customer loyalty, enhance the effectiveness of promotions, and serves as an opportunity to interact closer with mobile shoppers (Cameron, Gregory and Battaglia, 2012). While m-apps present huge potentials for consumers and are important to the organization's success, the studies are still in early stages. Most of previous research on m-apps in the mobile environment to date focused on themes such as the applicability of m-apps in library (Besara, 2012; Schnell, 2012), medical (Hasman, 2011; McGee, 2011;O'Hagan, 2012), science (Newman, 2012) and education (Roth, 2013). While a number of industrial and academic researchers are conscious on the relative importance of m-apps and their impact on the tourism industry, the study has not been research at this point. As there are over thousands of apps in Apple App Store and Google Android Market (Roth, 2013) and the high cost in developing m-apps which can range from £5,000 to £250,000 (Management Today, 2013), understanding the

motivation for consumers to adopt m-apps as a mean to purchase tourism related products and services remains crucial. There are several reasons why the study's focuses from the perspective like Malaysia. Statistics revealed that the mobile penetration rate in Malaysia is second highest in South East Asia at 140 percent (Forest Interactive, 2013). In addition, Chong, Chan and Ooi (2012), explained that developing markets provides a huge market opportunity for m-commerce practitioners. According to a 2012 study by Malaysia Communications and Multimedia Commission (2012), 27.4 percent of Malaysian smart phone owners own less than 10 apps. The findings of the study indicate that m-apps would have a greater chance to remain if the software is well designed from the consumers' perspective. Thus, the paper aim is on the factors leading to Malaysian consumers' intention to adopt m-apps as a mean to purchase tourism related products and services via their m-devices. The organization of the paper is as follows. First we present on past studies adopted for theoretical models. Next we describes on the hypotheses development and the research framework. The discussion on the implications, limitations, future research and conclusions are followed thereafter.

A REVIEW OF THEORETICAL MODELS OF INFORMATION TECHNOLOGY ACCEPTANCE

Several original theoretical frameworks have been proposed over the last 20 years to explain adoption behavior of new information technology (IT) and information system (IS). They mainly centered around "Technology Acceptance Model (TAM)", "Theory of Reason Action (TRA)", "Theory of Planned Behaviour (TPB)" and, "Diffusion of Innovation (DOI)" (Davis, 1989; Fishbein and Ajzen, 1975; Ajzen,1991; Rogers, 1995). A few of the models have been criticized in view of their limitations. Ajax and Azhar (2012) pointed out that some of the constructs remains simple and unimportant and thus suggested that the variables be replaced with other constructs that have greater importance in enhancing consumers purchase experience. Similarly, Zhang and Mao (2008) concluded that some of the models were not instructive without modifying the framework. As most of the frameworks fail to explain predictive capabilities and was developed using limited empirical evidence (Chaudhry et al., 2006), the study therefore decided to adopt the Unified Theory of Acceptance and Use of Technology (UTAUT) as the main framework in view that the model has been proven more superior than existing models (Venkatesh& Zhang, 2010) (see figure1).
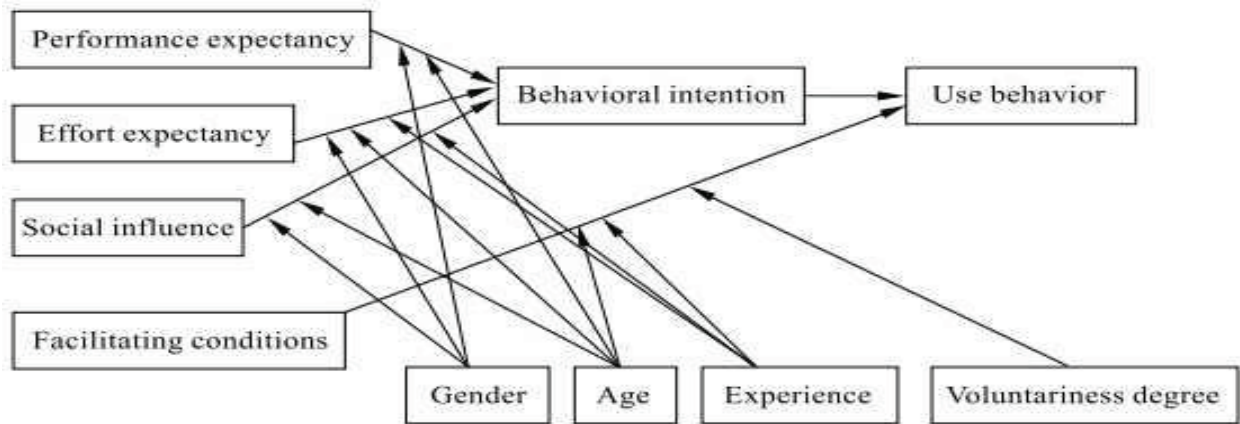
Figure 1: UTAUT

The model which comprises of four determinants of use namely performance expectancy (PE), effort expectancy (EE), social influence (SI) and facilitating conditions (FC) and four moderating variables such as gender, experience, age and voluntariness were build by integrating previous models developed from TAM, TPB, DOI, TRA, PC Utilization (MPTU), motivational model and Social Cognitive Theory (SCT) and combination of TAM and TPB (Venkatesh et al., 2003). UTAUT was discovered to surpass each of the individual models using results from 215 respondents from four organizations and can interpret consumers' behavioral intention as much as 70 percent and about 50 percent in actual use (Holden and Karsh, 2010). As purchasing tourism products and services using m-apps is still in its early infancy, intention was preferred over actual usage as a dependent variable (Wang and Wang, 2010). Moreover according to Yang (2013), there is strong relationship between intention to use m-apps and actual use. See figure 2 for the proposed research framework.
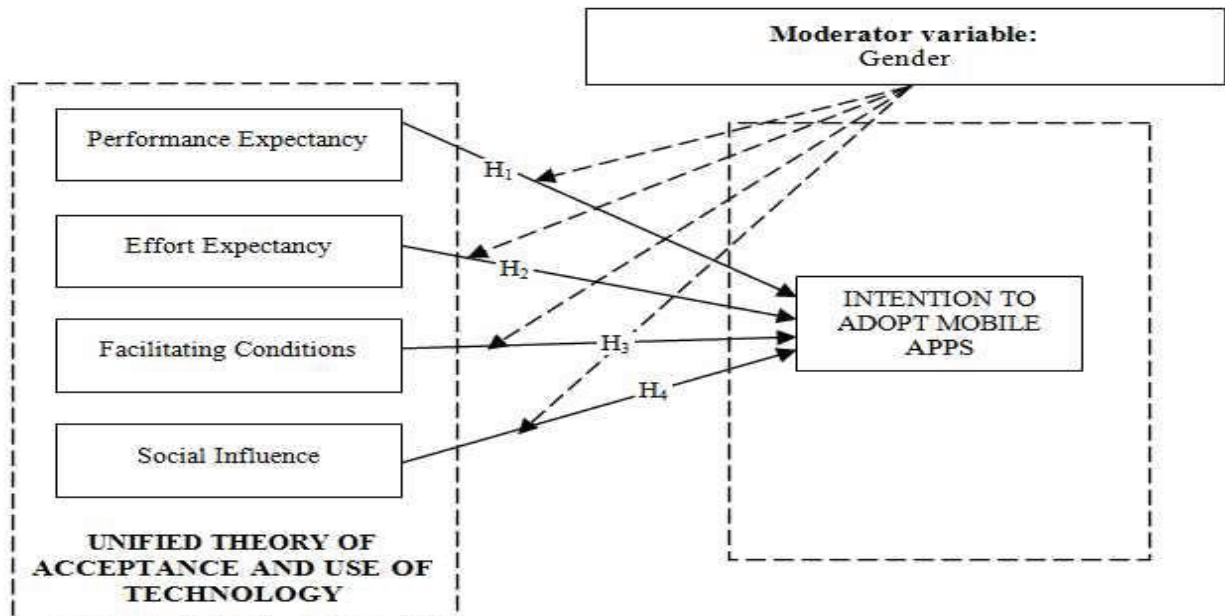
Figure 2: Proposed Research Framework

HYPOTHESES DEVELOPMENT

Performance expectancy (PE)

Performance expectancy (PE) is defined as "the degree to which an individual believes that using the system will help him or her to attain gains in job performance" (Venkatesh et al., 2003, p. 447). Adopting mobile hotel reservation (MHR) services as an example, Wang and Wang (2010), elaborated that the system can help to identify customers' preferences, routing information more conveniently and assist to locate hotel in the vicinity by relying on consumers' location via global positioning system. Besides, travel apps such as Trip Advisor, Expedia Hotels, Flights, Hotels.com and, etc, enables consumers to compare prices on flights, book car rentals and accommodations, access timely and accurate product information within the convenience of consumers' homes, 24/7/365. When consumers perceived that there are advantages using m-apps to book for tourism related products and services as opposed to the traditional channels such as m-sites, this will lead to higher adoption intention. Thus the following hypothesis has been formulated:

H1: EE has a significant relationship with the intention to adopt m-apps in Malaysia.

Effort expectancy (EE)

By using the definition from (Venkatesh et al., 2003, p. 450), effort expectancy in these study refer to "the degree of ease associated with the use of the system" and have been recognized to predict many IT adoption studies (Kijsanayotin, Pannarunothai and Stuart, 2009). Lu et al., (2009) using 1320 respondents, found that the adoption of mobile services is significantly influence by EE. One of the major transacting obstacles using m-devices is mainly due to their physical features. Chong, Chan and Ooi (2012) argued that mobile developers sacrifice features and functionalities over simple interface. Mobile scholars in Malaysia like Leong et al., (2013) and Tan et al. (2014) opined that the limited input facilities of m-devices leads to challenges in payment transactions whereby most m-devices are not optimized for online payment. M-apps however outperform the use of m-sites since the functions are displayed in one screen and designed specifically for shopping. When booking can be conducted using a few taps, this leads to ease of navigation and better customer experience. Consequently when consumers perceive that that m-apps requires less mental and physical efforts to use, this will lead to higher adoption intention and allows us to propose the following hypothesis:

H2: PE has a significant relationship with the intention to adopt m-apps in Malaysia.

Facilitating conditions (FC)

Venkatesh et al., (2003, p.453) defined facilitating conditions (FC) as the "degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system". In the study by Lu et al., (2008) on the acceptance of wireless mobile data services in China explained that FC comprises of two dimensions namely technology factors (e.g, compatibility issues) and resources factors (time and money) and must be present to encourage usage. Result by Chong (2013) shows that the intention to adopt m-commerce in China using 140 sample size and neural network analysis is significant with FC. Yang (2010) in their study on m-shopping in the United States found that the willingness of consumers will be higher if they have internet-enable m-devices, adequate knowledge and resources available. Theoretically m-apps may require some knowledge and ability to operate. While consumers may be willing to adopt m-apps, the impose limitations such lack of knowledge, training and technical support may shape their overall impression and hamper utilization. The tendency to adopt however will be likely if the obstacles can be removed and thus this leads us to the next hypothesis:

H3: EE has a significant relationship with the intention to adopt m-apps in Malaysia.

Social influence (SI)

As defined by (Venkatesh et al., 2003 p.451), social influence (SI) described the "degree to which an individual perceives that important others believe he or she should use the new system". Taylor and Todd (1995) and Bhattacherjee (2000) further decomposed the construct

into the following categories; influence of peers, superiors, interpersonal, and external influences. A number of mobile adoption studies reveal on the relationship between SI and intention with empirical evidence. This includes mobile searches (Zhang, Huang and Chen, 2010), mobile data service (Dimitrios et al, 2012), mobile learning (Tan et al., 2012) and m-commerce (Chong, 2013). Since the adoption of m-apps to purchase for tourism related products and services is still at the early product life cycle stage, consumers will be reluctant to adopt the technology. Hence they will consult their decisions with the social networks such as family members, friends and even peers when facing uncertainties (Burkhardt and Brass, 1990). Theoretically, when consumers perceived the importance of thoughts from people nearby, this leads to higher motivation to comply with certain behaviour. Thus this provide guidance to the following hypothesis being formulated:

H4: SI has a significant relationship with the intention to adopt m-apps in Malaysia.

Moderating effect: gender

Past literatures on adoption studies found that men and women have different perceptions on technology (Clegg and Trayhurn, 2000) as men are usually risk seeker when compared to women (Garbarino and Strahilevitz, 2004). Drawing from their research, Venkatesh et al., (2003) suggested than men shows stronger intention for PE whereas the effect of EE was stronger for women. Similarly, in an extended UTAUT study on the mobile banking intention in Taiwan, gender was also found to moderate PE whereby men rate PE higher compared to women (Yu, 2012).The rationale are that men are more objective-oriented and influence by goal accomplishment when compared to women (Cruz et al., 2010). Venkatesh, Morris and Ackerman (2000) further explained that women are sensitive to others' perspectives and prefer social interaction when forming their intention to adopt a new technology. Thus females reported to be influenced by subjective norms (Noble, Griffith and Adjei, 2006). Hence by investigating the moderating effect of gender, practitioners will gain better insights on how the adoption of m-apps is influenced by gender which bring us to the following hypothesis

H5: Gender moderates all relationships among variables in the research framework.

RESEARCH METHODOLOGY

Sampling and data collection

The survey was took place at one the private varsity in Malaysia. University students were our preference due to two reasons. Firstly according to a mobile researcher in Malaysia, young users have higher acceptance of new technologies adoption (Leong et al., 2011). Secondly, statistics by MCMC (2012) indicated that respondents with the age group of 20-24, 25-29 and 30-34 comprises of the largest hand phone users in Malaysia with 17.3%, 15.8% and 13.8%

respectively. 200 questionnaires were distributed over a week period in various classes after obtaining approval from the university management and 14 of the questionnaires were found to be incomplete, thus the effective effective rate was 93%.

DATA ANALYSES

Profile of respondents

Table 1 summarized the respondents' demographic profile. The gender distribution consists of 51.1% female while 48.9% are male respondents. The respondents age from 21-25 (70.4%), from 26-30 (3.2%), from 31-35 (0.5%) while below 20 is (25.8%). In terms of education level, a large portion of the respondents have a bachelor degree/professional qualification at 85.5%. Finally, 96.8% of the respondents are single.

Table 1: Demographic profile of respondents

Item		Frequency	Percent
Gender	Male	91	48.9
	Female	95	51.1
Age	Below 20	48	25.8
	21 – 25	131	70.4
	26 – 30	6	3.2
	31 – 35	1	0.5
Marital status	Single	180	96.8
	Married	6	3.2
Highest education level	No college degree	8	4.3
	Diploma/Advanced diploma	16	8.6
	Bachelor degree/Professional qualification	159	85.5
	Postgraduate qualification	3	1.6

Survey instruments

The 4 independent variables and dependent variable in Table 2 were adapted from past literatures and measured using score of 1-7 where 1 anchored from 'strongly disagree' to 7 'strongly agree'. Tourism professionals were consulted in order to validate the questionnaire. As a result, some ambiguous words were modified to improve the clarity of statement.

Table 2: Questionnaire source and number of items

Constructs	Number of Item	Sources
Performance Expectancy (PE)	4	Venkatesh et al., (2003)
Effort Expectancy (EE)	4	Venkatesh et al., (2003)
Facilitating Conditions (FC)	4	Venkatesh et al., (2003)
Social Influence (SI)	4	Venkatesh et al., (2003)
Intention to use (IU)	3	Tan et al. (2014)

Statistical analysis

Partial Least Square Structural Equation Modelling (PLS-SEM) approach using Smart-PLS 2.0 was adopted to test the research model (Ringle et al., 2005; Chan et al., 2010).Thong (2001) commented that PLS-SEM is a powerful approach which can be adopted to test the research hypotheses.

Measurements

Internal reliability, convergent validity, and discriminate validity were evaluated at this stage. All factor loadings and composite reliability should be greater than 0.70 in order for the tests to be statistically accepted (Fornell and Lacker, 1981). The average variance extracted (AVE) values should also be above 0.50. Based on the figures in Table 3, the suggestion has been fulfilled by the measurement model. Fornell and Lacker also suggested that the square roots of the AVEs should be greater than the correlation shared between the two constructs in examining the discriminate validity. Likewise the discriminant validity has been achieved by the measurement model as shown in Table 4.

Table 3: Factor Loadings, AVE, Composite Reliability and Internal Relibility

Constructs	Items	Loadings	AVE	CR	IR
Behavioral Intention (BI)	BI2	0.9547	0.9146	0.9554	0.9006
	BI3	0.9580			
Effort Expectancy (EE)	EE1	0.8135	0.7522	0.9238	0.8901
	EE2	0.888			
	EE3	0.8939			
	EE4	0.8707			
Facilitating Conditions (FC)	FC1	0.9095	0.7856	0.9361	0.9091
	FC2	0.8775			
	FC3	0.8922			
	FC4	0.8749			
Performance Expectancy (PE)	PE1	0.8521	0.7886	0.9371	0.9106

Constructs	Items	Loadings	AVE	CR	IR
	PE2	0.9066			
	PE3	0.9001			
	PE4	0.8922			
Social Influence (SI)	SI1	0.8769	0.7807	0.9343	0.9059
	SI2	0.9213			
	SI3	0.9053			
	SI4	0.8280			

Note: AVE = Average Extracted Variance; CR = Composite Reliability; IR = Internal Reliability; Item BI1 was deleted due to low factor loading

Table 4: Discriminant Validity test for the measurement model in PLS

	BI	EE	FC	PE	SI
BI	**0.9563**				
EE	0.6242	**0.8673**			
FC	0.8257	0.6764	**0.8863**		
PE	0.4879	0.6959	0.5795	**0.8880**	
SI	0.7329	0.6910	0.7665	0.5822	**0.8836**

Note: Diagonal elements (bold) are the square root of the AVE for each construct. Off-diagonal factors demonstrate the inter-correlations.

Hypothesis tests for structural model

The results as shown in Table 5 indicates that FC (β = 0.6321, p < 0.01) and SI (β = 0.2298, p < 0.01) had significant and positive relationship with BI. FC, EE, PE and SI could be explained by the 71.0% of variance in BI. Hence, H3 and H4 of the hypotheses were supported. EE (β = 0.089, p > 0.01) and PE (β = -0.075, p > 0.01) on the other hand had insignificant relationship with BI and hence, H1 and H2 were not supported.

Table 5: Hypotheses Testing

| | Dependent Variable |
	Intention to use Mobile Apps
R^2	0.710
Efforts Expectancy	0.089
Facilitating Conditions	0.6321**
Performance Expectancy	-0.075
Social Influence	0.2298**

**Note: **p-value < 0.01

72.58% of the variance in BI can be explained by EE, PE, FC and SI as indicated in Table 6 with regards to the moderating effects of gender on the UTAUT constructs towards BI to use m-apps. Gender was found to have significantly and negatively moderated effect on the relationship between SI and BI while EE and PE to BI to use m-apps were not significantly moderated by gender. Thus, in comparison to their male users, female users have higher tendency in perceiving SI as a factor that influence their intention to adopt m-apps.

Table 6: PLS results with moderators (Gender)

| | Dependent Variable | |
	Intention	**Supported**
R^2	0.7258	No
Efforts Expectancy	0.0920	No
Facilitating Conditions	**0.6207****	**Yes**
Performance Expectancy	-0.0810	No
Social Influence	**0.2431****	**Yes**
Efforts Expectancy x Gender	0.0920	No
Facilitating Conditions x Gender	0.0773	No
Performance x Gender	0.0325	No
Social Influence x Gender	-0.1740*	Yes

**Note: **p-value < 0.01; *p-value < 0.05;

DISCUSSION

The current study found that PE is non-significant with consumers' intention to adopt m-apps. The study however is in disagreement with past studies such as m-commerce adoption in China (Chong, 2013) and Macau (Lai and Lai, 2014). The findings is however consistent with an

empirical research conducted by Chong et al., (2012) in Malaysia and China whereby usefulness was also found have no significant relationships with the intention to adopt m-commerce. While Fulgoni and Lipsman (2011) provide a statistic breakdown whereby; 50 percent of smartphone users access m-apps to locate nearby stores, 38 percent to compare prices while another 29 percent to access for bargain dealings, this may not necessary translate to advantages in job performance as travelling for students is only done occasionally. Likewise, EE is also a non-significant factor in predicting the intention to adopt m-apps. The finding corroborates the findings on other mobile studies, for instance mobile banking adoption in Taiwan (Yu, 2012), and m-commerce adoption in Macau (Lai and Lai, 2014). The result indicates that consumers do not give emphasis on the 'easy to use' feature. The finding is not surprised since most m-apps features are user friendly and well-designed. Wang and Wang (2010), provide evidences that the procedure to book for a hotel room can be conducted in a breeze manner based on a few taps. The finding however contradicts with the study by Chong (2013) in China, whereby EE was found to be a significant factor with the intention to adopt m-commerce. The finding also revealed that FC is a significant constructs in predicting the adoption of m-apps. Chong (2013) using UTAUT as their main model also found that FC is one of the significant predictor of BI for m-commerce in China. The finding is not surprised since most apps available are equipped with FAQ and technical supports. SI on the other hand is another predictor of m-apps adoption and was supported by UTAUT studies such as m-commerce adoption (Chong, 2013), and mobile search (Zhang, Huang and Chen, 2010) in China. The result is also similar with the findings by a Malaysian researcher whereby they discovered that young Malaysia users are easily influenced by friends, colleagues, mass-media in the adoption of mobile entertainment (Leong et al., 2013). Therefore, practitioners should consider promoting m-apps using social media sites as a strategy to penetrate the untapped market. In terms of moderating variable, FC, EE and PE were not significantly moderated by gender. The finding is similar with the study on mobile banking in Taiwan whereby EE was also found not moderated by gender (Yu, 2012). Another study in Malaysia by Leong et al., (2013) also revealed that advantages and ease of use on mobile entertainment were not significant moderated by gender. Interestingly gender only moderates the relationship between SI and intention. The study however contradicts with findings by Borrero et al., (2014) on social network sites and Zhang, Huang and Chen (2010), on mobile search technology. The findings concur that the decision making of female users tends to be determined by the opinion of others (Venkatesh and Morris, 2000).

IMPLICATIONS

The study has several implications which may be useful when rendering m-apps services for consumers by researchers, mobile apps developers, travel related organizations and even government agencies. From the theoretical perspectives the study adopted the UTAUT model. Hence this contributes to the scare literatures on m-apps in tourism. In terms of managerial

implications, considering that SI is an important factor influencing on the intention to adopt, opinion of friends, family members, mass-medias' matters. Thus SI can be implemented by integrating a sharing button in the apps software with social network sites. In addition, a mobile review sites should be made available when consumers shop using m-apps. Regarding FC, practitioners must provide adequate resources and support for consumers. This may include toll free customer care numbers, SMS and WhatsApp support, active presence in social sites, emails supports, workshop, when consumers encountered problem using m-apps to purchase. Finally, on the moderating effect of gender, since female users based their decision making on social interaction, customized marking approach should be adopted for the needs of this segment market.

LIMITATION AND FUTURE STUDIES

Although thorough considerations have been established to make certain that the methodology is valid, there are nevertheless limitations that may warrant future research. First, the study surveyed students at one of the varsity in Malaysia. Cautious therefore should be exercised when generalizing the studies to non-comparable populations. Future studies may include the study using different populations. The second limitation arises from the adoption of behavioural intention as a measurement for actual use. While many IT adoption studies have found strong relationship between intention to use and actual use, the adopted measurement may weakened the explanatory power of the model. Considering this limitation, scholars could adopt actual usage in their future studies. Another limitation is that our study only includes age as a moderating variable. Other social-demographic variables e.g., occupation, education, income, age should be considered for future research. Finally, there are other antecedents such as perceived financial costs, perceived service quality, perceived value, and etc that may adopted in facilitating the understanding on the intention to adopt. However they were neglected to keep the research simple. Thus, in order to add richness, future research can place emphasis on the constructs in helping to provide a more comprehensive understanding.

CONCLUSION

Understanding how consumers behave in a mobile environment have becomes more critical and have implications on the organizations' business strategy. The study contributes by providing better explanation on the Malaysian consumers' intention to adopt m-apps for purchasing tourism related products and services. Thus, the study will be useful for mobile developers, tourism related organizations and even government agencies in helping them to promote m-apps as the preferred medium to purchasing online and when formulating appropriate strategies.

ACKNOWLEDGEMENT

REFERENCES

1. Ajax, P., and Azhar, I. (2012), "Innovative mobile marketing via smartphones Are consumers ready?",*Marketing Intelligence & Planning*, Vol. 30 No. 4, pp. 418-443.
2. Ajzen, I. (1991), "The theory of planned behavior", *Organisational Behaviour and Human Decision Processes*, Vol. 50, pp. 179-211.
3. Besara, R. (2012), "Using Mobile Tools for Advocacy", The *Reference Librarian*, Vol. 53 No. 2, pp. 297-303.
4. Bhattacherjee, A. (2000), "Acceptance of Internet applications services: The case of electronic brokerages", *IEEE Transactions on Systems, Man, and Cybernetics* - Part A: Systems and Humans, Vol. 30 No. 4, pp. 411-420.
5. Borrero, J.D., Yousafzai, S.Y., Javed, U., and Page. K.L (2014), "Expressive participation in Internet social movements: Testing the moderating effect of technology readiness and sex on student SNS use", *Computers in Human Behavior,* Vol. 30 pp. 39-49.
6. Burkhardt, M.E., Brass, D.J., (1990), "Changing patterns or patterns of change: the effects of a change in technology on social network structure and power", *Administrative Science Quarterly*, Vol. 35 No. 1, pp. 104–127.
7. Cameron, D., Gregory, C., and Battglia,D. (2012), "Nielsen Personalizes The Mobile Shopping App If You Build the Technology, They Will Come, Journal of Advertising Research, Vol. 52 No 3, pp. 333-338.
8. Chan, F.K.Y., Thong, J.Y.L., Venkatesh, V., Brown, S.A., Hu, P.J.H., and Tam, K.Y. (2010), "Modeling citizen satisfaction with mandatory adoption of an e-government technology", *Journal of the Association for Information Systems*, Vol. 11 No. 10, pp.519-549.
9. Chaudhry, B., Wang, J., Wu, S., Maglione, M., Mojica, W., Roth, E. (2006), "Systematic review: impact of health information technology on quality, efficiency, and costs of medical care". *Annals of Internal Medicine*, Vol. 144 No. 10, pp. 742–52.
10. Chong, A.Y.L. (2013), "Predicting m-commerce adoption determinants: A neural network approach", *Expert Systems with Applications*, Vol. 40 No. 2, pp. 523–530.
11. Chong, A.Y.L., Chan, F.T.S., and Ooi, K.B. (2012) "Consumer decision to adopt m-commerce: A cross country empirical examinations between China and Malaysia, Decision Support Systems, Vol. 53 No. 1, pp. 34-43.
12. Clegg, S., &Trayhurn, D. (2000). Gender and computing: Not the same old problem. British Educational Research Journal, 26(1), 75–90.

13. Cruz, P., Neto, L. B. F., Munoz-Gallego, P., and Laukkanen T. (2010), "Mobile banking rollout in emerging markets: Evidence from Brazil," *International Journal of Bank Marketing*, Vol. 28 No. 5, pp. 342-371.

14. Davis, F.D. (1989), Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly* 13 (3), pp. 319–340.

15. Dholakia, R. R. (2012), "Technology and Consumption, International Serieson Consumer Science", DOI: 10.1007/978-1-4614-2158-0_4

16. Dimitrios, C. K., Dimitris, A. D., Tsiaousis, A.S., Giaglis, G.M., and Fouskas, K.G. (2012), "Affective and social determinants of mobile data services adoption", *Behaviour & Information Technology,* Vol. 31 No. 3, pp. 209–219.

17. Fishbein, M., and Ajzen, I. (1975), Belief, Attitude, Intention, and Behavior: An Introduction to Theory and Research. *Reading*, MA: Addison-Wesley.

18. Forest Interactive (2013). Mobile Penetration Rate 2013, available at http://www.forest-interactive.com/mobile-penetration-rate-2013-2/ (accessed 16 March 2014)

19. Fornell, C., and Larcker, D.F. (1981), "Evaluating structural equation models with unobservable variables and measurement error", *Journal of Marketing Research*, Vol. 18 No. 1, pp.39-50.

20. Frizzo-Barker, J., and Chow-White, P.A. (2012), "There's an App for That" Mediating mobile moms and connected careerists through smartphones and networked individualism", *Feminist Media Studies*, Vol. 12 No. 4, pp. 580-589.

21. Fulgoni G., and Lipsman, A. (2011), "State of the U.S. online retail economy in Q1 2011". Available at: comScore.com Retrieved 26 March 2014.

22. Garbarino, E., and M. Strahilevitz. (2004), "Gender differences in the perceived risk of buying online and the effects of receiving a site recommendation," *Journal of Business Research*, Vol. 57 No. 7 pp. 768-775, 2004.

23. Hasman, L. (2011), "An Introduction to Consumer Health Apps for the iPhone" „*Journal of Consumer Health on the Internet*, Vol. 15 No. 4, pp. 322–329.

24. Holden, R.J., and Karsh, B.T. (2010). "The Technology Acceptance Model: Its past and its future in health care", *Journal of Biomedical Informatics,* Vol.43 No.1, pp. 159-172.

25. Kijsanayotin, B., Pannarunothai, S., and Stuart, M.S. (2009), "Factors influencing health information technology adoption in Thailand's community health centers: Applying the UTAUT model", *International journal of medical informatics*, Vol. 78 No. 6, pp. 404-416.

26. Kim, E., Lin, J.S., and Sung, Y. (2013), "To App or Not to App: Engaging Consumers via Branded Mobile Apps", *Journal of Interactive Advertising*, Vol. 13 No. 1 pp. 53-65.

27. Lai, I.K.W., and Lai, D.C.F. (2014), "User acceptance of mobile commerce: an empirical study in Macau", *International Journal of Systems Science*, Vol. 45 No.6, pp. 1-11.

28. Leong, L.Y., Ooi, K.B., Chong, A.YL., and Lin, B. (2013), "Modeling the stimulators of the behavioural intention to use mobile entertainment: Does gender really matter?", *Computers in Human Behavior*, Vol 29 pp.2109-2121.

29. Lu, J., C. S. Yu, and C. Liu, "Mobile data service demographics in urban China," *The Journal of Computer Information Systems*, Vol. 50, No. 2: 117-126, 2009.

30. Lu, J., Liu, C., Yu, C.S., and Wang. K. (2008), "Determinants of accepting wireless mobile data services in China", *Information & Management, Vol.* 45 No. 1, pp.52-64.

31. Malaysia Communications and Multimedia Commission (MCMC), 2012. *Hand phone users survey 2012: Statistical brief number fourteen*. Retrieved November 2, 2013, fromhttp://www.skmm.gov.my/skmmgovmy/media/General/pdf/130717_HPUS2012.pdf

32. Management Today (2013), "Who's Winning the App Games", pp. 48-51.

33. McGee (2011), "Mobile Contact Tracing and Counseling for STI's: There's Not an App for That Summer", *The American Journal of Bioethics*, Vol. 11 No. 5, pp. 3-4.

34. Newman, S.A. (2012), "Synthetic Biology: Life as App Store", *Capitalism Nature Socialism*, Vol. 23 No. 1,pp. 6-18.

35. Noble, SM., Griffith DA., Adjei, M.T. (2006), "Drivers of local merchant loyalty: understanding the influence of gender and shopping motives", *Journal of Retailing*, Vol. 82 No. 3, pp. 177-188.

36. O'Hagan, E. (2012), "Getting Started with Medical Apps: Apps You Should Know About|, *Journal of Hospital Librarianship*, Vol. 12 No. 2, pp. 162-170.

37. Purcell, K., Entner, R., and Henderson, N. (2010), The Rise of Apps Culture, Internet and American Life Project, available at http://www.pewinternet.org/Reports/2010/The-Rise-of-Apps-Culture.aspx (accessed 16 March 2014)

38. Research and Markets. (2012), "The Apps Statbook 2011," http://www.researchandmarkets.com/reports/1884410/the_apps_statbook_2011, (accessed 16 March 2014).

39. Ringle, C.M., Wende, S., and Will, A. (2005), "*Smart PLS 2.0*". University of Hamburg, Hamburg, Germany.

40. Rogers, E.M. (1995), Diffusion of Innovations, 4th ed., *The Free Press*, New York, NY.

41. Roth.K. (2013), "Adapt with Apps", *Journal of Physical Education, Recreation & Dance Publication*, Vol. 84 No. 2, pp.4-6.

42. Schnell E. MLS. (2012), "The Mobile Medical Library – Is There an App for That?"„*Journal of Electronic Resources in Medical Libraries*, Vol. 9, No. 2, pp. 9147-154.

43. Tan, G. W. H., Sim, J.J., Ooi, K.B., and Kongkiti, P. (2012), "Determinants of mobile learning adoption: An empirical analysis", *Journal of Computer Information System*, Vol. 52 No. 3, pp. 82-91.

44. Tan, G.W.H., Ooi, K.B., Chong, S.C. and Hew, T.S. (2014), "NFC mobile credit card: the next frontier of mobile payment?", *Telematics and Informatics*, Vol 31 No 2, pp. 292-307

45. Taylor, S., and Todd, P.A. (1995), "Assessing IT usage: the role of prior experience", *MIS Quarterly*, Vol. 19 No. 2, pp. 561-70.

46. Thong, J.Y.L. (2001), "Resources constraints and information systems implementation in Singaporean small business", *Omega*, Vol. 29, pp.143–156.

47. Venkatesh, V., and Zhang, X. (2010), "Unified theory of acceptance and use of technology: U.S. vs. China," *Journal of Global Information Technology Management*, Vol. 13 No. 1, pp. 5-27, 2010.

48. Venkatesh, V., Morris, M.G., Davis, G.B., and Davis, F.D. (2003), "User Acceptance of Information Technology: Toward a unified views, *MIS Quarterly*, Vol. 27 No. 3, pp. 425-478.

49. Venkatesh, V., and Morris, M. G. (2000), "Why don't men ever stop to ask for directions? Gender, social influence, and their role in technology acceptance and usage behavior", *MIS Quarterly*, 24(1), 115-139.

50. Venkatesh, V., Morris, G. M., and Ackerman, P. L. (2000), "A longitudinal field investigation of gender differences in individual technology adoption decision making processes", *Organizational Behaviour and Human Decision Processes*, Vol. 83 No.1, pp. 33–60.

51. Wang, H.Y., and Wang, S.H. (2010), "Predicting mobile hotel reservation adoption: Insight from a perceived value standpoint", *International Journal of Hospitality Management*, Vol. 29 No. 4, pp. 598–608.

52. Wong, C.H., Lee, H.S, Lim, Y.H., Chua, B.H., and Tan, G.W.H. (2012), "Predicting the Consumers' Intention to adopt Mobile-shopping: An Emerging Market Perspective", *International Journal of Network and Mobile Technologies,* Vol. 3 No. 3, pp. 24-39.

53. Yang, K. (2010), "Determinants of US consumer mobile shopping services adoption: implications for designing mobile shopping services", *Journal of Consumer Marketing*, Vol. 27 No. 3, pp. 262–270.

54. Yang, H. (2013), "Bon Appétit for Apps: Young American Consumers Acceptance of Mobile Applications," *Journal of Computer Information Systems*, Vol. 53 No. 3, pp. 85-96.

55. Yu, C.S. (2012), "Factors affecting individuals to adopt mobile banking: Empirical evidence from the UTAUT model", *Journal of Electronic Commerce Research*, Vol. 13 No. 2, pp. 104-120.

56. Zhang, J., and Mao, E. (2008), "Understanding the acceptance of mobile SMS advertising among young Chinese consumers", *Psychology & Marketing*, Vol. 25 No. 8, pp. 787-805.

57. Zhang, J., Huang, J., and Chen J. (2010), "Empirical Research on User Acceptance of Mobile Searches", *Tsinghua Science and Technology*, Vol. 15 No. 2, pp. 235-245.

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SUSTAINABLE PRODUCT DEVELOPMENT BASED ON AXIOMATIC DESIGN PRINCIPLES: A CASE STUDY

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ABSTRACT

Purpose: Due to rising environmental issues, together with public pressure and stricter regulations, firms and companies are changing their ways of developing new products. In order to achieve sustainable product realization, three key areas namely end-of-line (EOL) management, green supply chain and sustainable manufacturing have to be taken into account during design stage. The purpose of this paper is to propose a framework based on axiomatic design (AD) principles to facilitate sustainable product development by aiding the decision making process in the abovementioned key areas.

Methodology: By using the development of media player housing as example, case studies are presented in this paper to demonstrate the application of axiomatic design principles in the areas of design for EOL management, green supplier selection and optimization for sustainable manufacturing.

Findings: Results show that axiomatic design principles are able to guide designer/engineer in selecting functional embodiment that facilitates product recovery and fuzzy axiomatic design approach can be effective when dealing with problems concerning green supplier selection and optimization of manufacturing solution. Hence, a framework for sustainable product realization is proposed in the last section of this paper with a vision of providing guideline for companies in designing and developing electronic products that are less harmful to the environment.

Originality: Studies between the years of 2009 and 2013 have been researched by using key words such as "Axiomatic design", "Sustainability", and "Sustainable Product Development". As a result, no similar research work (i.e. application of axiomatic design principles in the areas of design for EOL management, green supplier selection and sustainable manufacturing to construct a holistic framework for sustainable product development) has been discovered. Therefore, this is the first publication that presents the case study.

Keywords: axiomatic design, sustainable product development, design for EOL management, green supplier selection, sustainable manufacturing.

INTRODUCTION

The human population increased from less than 2 billion to over 6 billion people during the 20th century and the largest cities in the world currently contain a total of 30 million people. Each year, 7 billion tons of carbon dioxide is added to the atmosphere by worldwide human activities (Ayres and Ayres, 2002). In 2006, the U.S. manufacturing sector recorded an output with gross value of $5.3 trillion (in the form of a variety of products) (BEA, 2008). About 84% of energy-related carbon dioxide emissions and 90% of the energy consumption can be attributed to these products (EIA, 2006). More and more products are being produced to provide services or to be consumed by people directly as a result of population growth and the improvement in the quality of life (Chertow, 2000), which further complicates environmental sustainability challenge and thus, it is important to reduce environmental footprints associated with these products in order to address environmental issues (Ramani *et al.*, 2010).

Worsening environmental issues, together with public pressure and more stringent regulations are the fundamental factors that impact the way firms/companies design and release new products globally (Choi *et al.*, 2008). Hence, firms/companies are being held responsible for producing products in an environmentally friendly way (Ramani *et al.*, 2010). This demands proper training in the context of sustainability (along with a global perspective) for the next generation of engineers with the aim of solving sustainability problems on multiple scales (Miheclic *et al.*, 2008).

SUSTAINABLE PRODUCT DEVELOPMENT

Other than end-of-life (EOL) management and recycling of products, sustainable product development requires a shared responsibility to implement and realize sustainability throughout the life cycle. Figure 1 shows the necessary considerations to be taken account during the design stage to attain sustainable product development which include downstream issues such as supply chain and manufacturing (Ramani *et al.*, 2010).

End-of-life (EOL) management is described as a process of converting EOL products into re-marketable products, components, or materials (Ramani *et al.*, 2010) and product design is the most important factor in achieving profitable EOL management (Ramani *et al.*, 2010, Kwak and Kim, 2010).
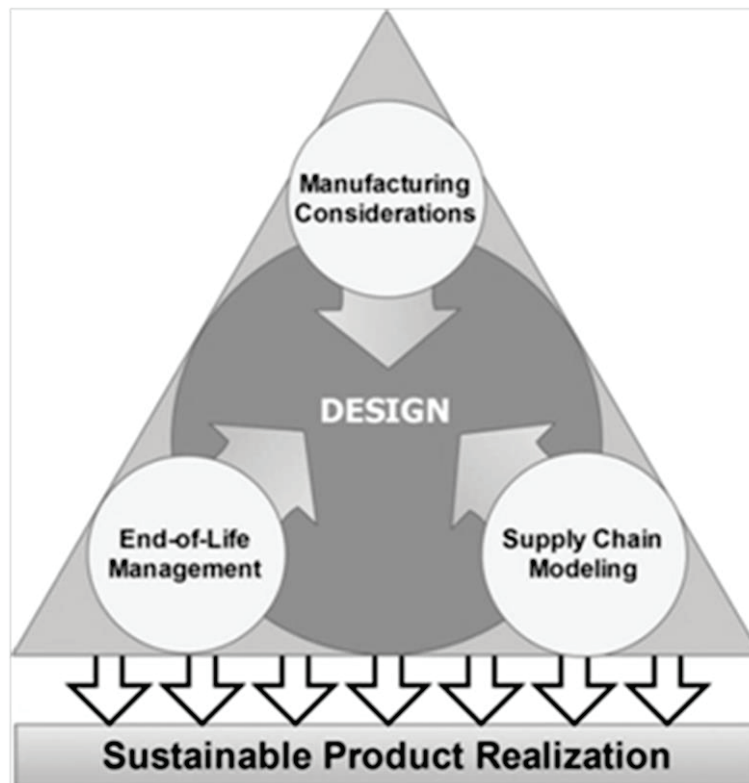
Figure 1. Design decisions affect every stage of a product's life (Ramani *et al.*, 2010).

Green purchasing can be defined as an environmentally conscious purchasing practice that reduces sources of waste and promotes the recycling and reclamation of purchased materials (Min and Galle, 2001). It is a boundary-spanning function within the supply chain (Webster, 1992; Leenders and Fearon, 1993; Williams *et al*., 1994). Furthermore, it is deemed as a firm's gate-keeper that influences forward flow and material quality (Preuss, 2001). Green *et al.* (1998) highlighted that purchasing is potentially a more powerful agent of change as compared with any other corporate function. Quite similarly, Preuss (2001) suggested that purchasing is an important agent for changing environmental initiatives in the supply chain and Min and Galle (1997) also stated that incorporating a company's environmental goals with purchasing activities is essential because purchasing is at the beginning of the green supply chain.

The product manufacturing process is seen as the main stage in the life cycle that involves direct resource consumption and is responsible for producing environmental pollutant. Also, in terms of sustainable development, it is the main factor that impacts the result of company's performance (Gutowski, 2004). Process improvement and optimization is one of the efforts to minimize the environmental impacts of manufacturing processes (Ramani *et al.*, 2010). Process optimization allows trade-off among performance and sustainability measures to be made, and therefore to provide the optimal combinations of operating parameters and to propose ways of enhancing and improving sustainability level (Wanigarathne *et al*., 2004).

In this paper, a case study is presented to demonstrate the application of axiomatic design principles in the abovementioned areas (i.e. design for EOL management, green supplier selection and manufacturing process optimization) with the aim of achieving sustainable product development.

CASE STUDY

A case study that involves the development of an electronic device (media player) is presented in the section owing to the fact that such products tend to become obsolete frequently due to the rapid advancement of technology in the industry (Silva *et al*., 2004). For the sake of simplicity, this case study only takes the closed-back housing into account. Development of other components such as circuit board, buttons and transparent window is not considered herein.

1. Design for EOL Management

This section focuses on application of axiomatic design in producing enhanced product architecture in terms of recovery potential that subsequently leads to a higher recovery profit in the event of replacing defective transparent window as part of the product refurbishment process.

In a patent document filed by Weber *et al*. (2012), it is highlighted that there are several possible embodiments of closed-back housing. Figure 2 shows the top plan view of a screen portion of a media player while Figure 3 reveals the cross-sectional views (of each embodiment) taken from line A-A of Figure 2. Embodiment 1 allows transparent window to mate with undercut and sit higher in the housing. On the other hand, Embodiment 2 features an overcut that allows mating with transparent window while in Embodiment 3, transparent window rests directly on the inner surface of the housing without undercut areas.
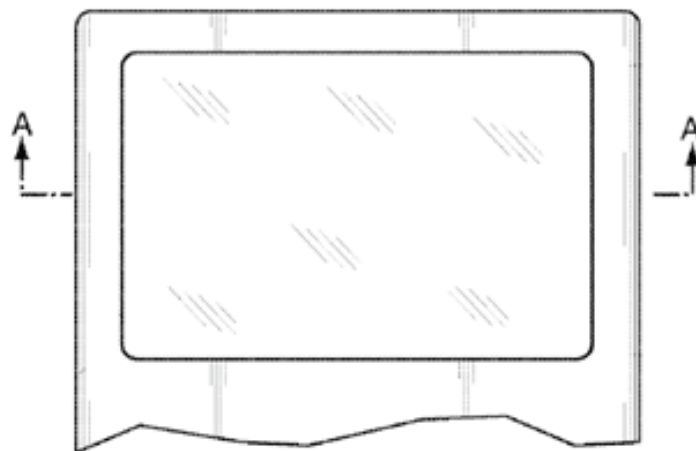
Figure 2. Top plan view: Screen portion of a media player (Weber *et al*., 2012).
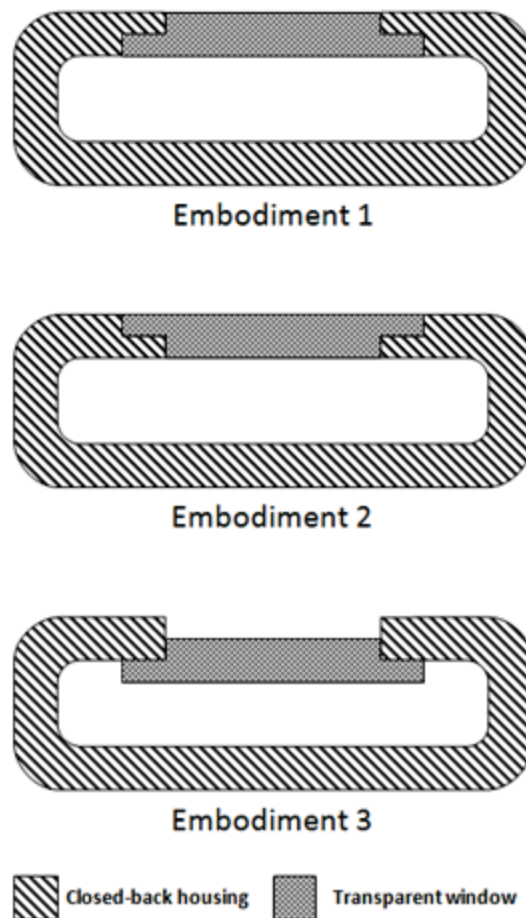
Figure 3. Cross-sectional view of each embodiment (Weber *et al*., 2012).

Within the same literature, it is also identified that functional requirements (FRs) and design parameters (DPs) listed in Figure 4 are essential to produce a workable design of a closed-back housing ('D' denotes product design). The relationship between the FRs and DPs can be represented with design matrix that characterizes the design as shown in Figure 5. With FRs and DPs set as such, both Embodiment 1 and Embodiment 2 would be acceptable as workable housing design. Whereas, Embodiment 3 should be discarded as it does not fulfill $FR_{D,3}$. This embodiment is being used in "conventional media player" and the inner space of the housing is occupied by the thickness of the window (Weber *et al*., 2012).

FR$_{D,1}$	To provide protection for internal components.	
FR$_{D,2}$	To enable viewing of display screen through housing.	
FR$_{D,3}$	To maximize volume available to store components without increasing the device size.	
DP$_{D,1}$	Maintain substantial overall housing thickness.	
DP$_{D,2}$	Introduce an opening on housing which is covered by transparent window.	
DP$_{D,3}$	An area of reduced thickness around the opening that allows transparent window to abut.	

Figure 4. FRs and DPs of a closed-back media player housing (Weber *et al.*, 2012)

	DP$_{D,1}$	DP$_{D,2}$	DP$_{D,3}$
FR$_{D,1}$	X	0	0
FR$_{D,2}$	0	X	0
FR$_{D,3}$	X	0	X

Figure 5. Design matrix that represents the relationship between FRs and DPs.

However, if recovery-related FRs and DPs were included during the problem definition stage (as shown in Figure 6, denoted by FR$_{D,4}$ and DP$_{D,4}$), Embodiment 1 would be ruled out as well since it requires additional effort to remove and replace the transparent window during recovery process.

$FR_{D,1}$	To provide protection for internal components.
$FR_{D,2}$	To enable viewing of display screen through housing.
$FR_{D,3}$	To maximize volume available to store components without increasing the device size.
$FR_{D,4}$	Easier or more economical disassembly of the parts in the product [Chen, 2001].
	$FR_{D,41}$ Fewer parts needed for disassembly in a disassembled unit.
	$FR_{D,42}$ Easy disassembly operations for the parts in the disassembled unit.

$DP_{D,1}$	Maintain substantial overall housing thickness.
$DP_{D,2}$	Introduce an opening on housing which is covered by transparent window.
$DP_{D,3}$	An area of reduced thickness around the opening that allows transparent window to abut.
$DP_{D,4}$	Defective window to be replaced by minimal recovery operations [Chen, 2001].
	$DP_{D,41}$ Reduce the number of parts needed for disassembly.
	$DP_{D,42}$ Design the parts with ease of disassembly.

Figure 6. Additional $FR_{D,4}$ and $DP_{D,4}$ are added to the original set of FRs and DPs.

	$DP_{D,1}$	$DP_{D,2}$	$DP_{D,3}$	$DP_{D,4}$	$DP_{D,41}$	$DP_{D,42}$
$FR_{D,1}$	X	0	0	0	0	0
$FR_{D,2}$	0	X	0	0	0	0
$FR_{D,3}$	X	0	X	0	0	0
$FR_{D,4}$	0	0	0	X	0	0
$FR_{D,41}$	0	0	0	0	X	0
$FR_{D,42}$	0	0	0	0	X	X

Figure 7. Design matrix with recovery-related FRs and DPs included.

As illustrated in Figure 8, Embodiment 1 requires additional procedure in order to disassemble the media player and to remove the transparent window. The top and bottom bezels need to be pried open to reveal the fasteners underneath. Then, it is necessary to unfasten those fasteners before the transparent window can slide out of the housing. This procedure has to be reversed when reassembling the transparent window (i.e. sliding the window into the housing, fastening screws and putting on the bezels). In contrast, the transparent window can be removed more easily from the housing if Embodiment 2 was adopted (see Figure 9). It can be achieved by simply prying the window after heating the adhesive with a blower. This embodiment also facilitates the reassembly process as the transparent window may be adhered directly onto the housing without having to place the window into the housing.
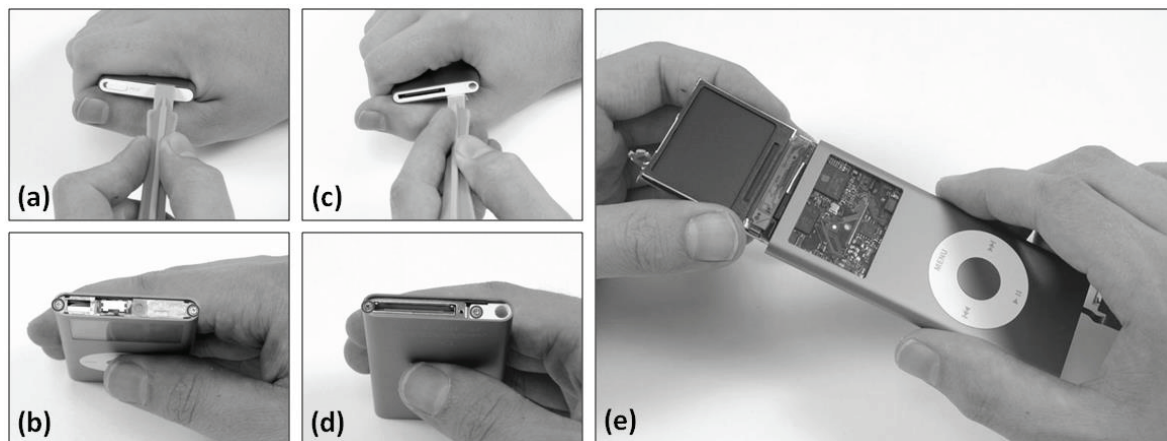
Figure 8. An example of Embodiment 1 and Embodiment 3 (iFixit.com, 2006).
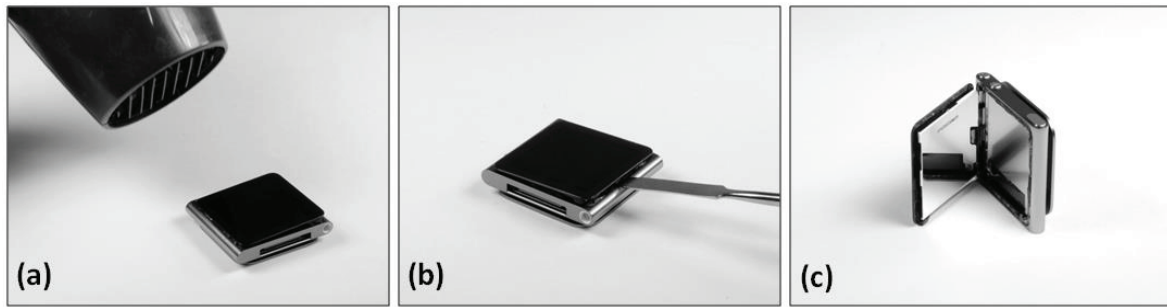
Figure 9. An example of Embodiment 2 (Detwiler, 2010).

2. Green Supplier Selection: Procurement of Raw Material

In this section, the study concentrates on the analysis of suppliers' environmental capability as part of green supplier selection process during the procurement of raw material for the manufacturing of closed-back housing.

Supplier selection is a process of selecting key suppliers based on a pre-established set of criteria. Environmental criteria can be categorized into two broad groups of qualitative and quantitative criteria. One or both groups of criteria may be utilized at the same time for green supplier selection depending on environmental management strategy used by an organization (i.e. reactive or proactive). If the buyer is evaluated to be practicing reactive strategy, it should only consider the quantitative environmental capability of its suppliers' during the selection process. In contrast, if the evaluation shows that the buyer is proactive, it should consider both quantitative and qualitative environmental factors for its suppliers during the selection process (Humphreys *et al.*, 2003). A systematic model of the environmental framework is shown in Figure 10.
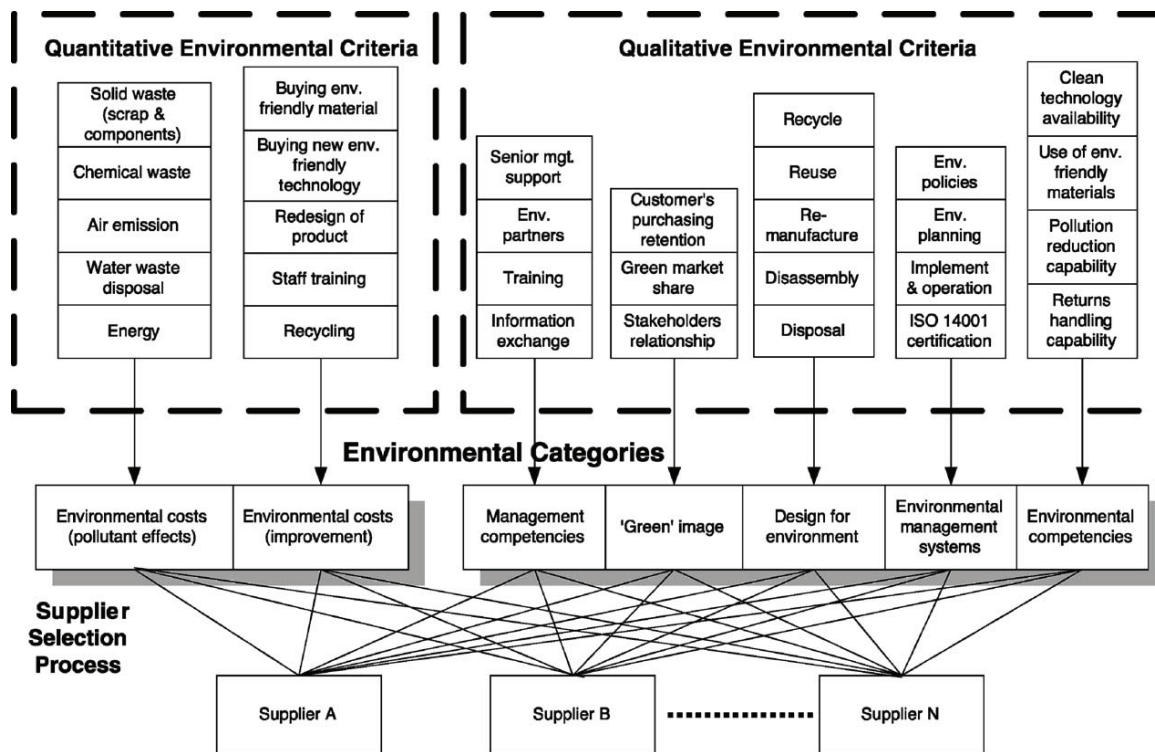
Figure 10. Environmental framework for incorporating environmental criteria into the supplier selection process (Humphreys *et al*., 2003)

The selection of green supplier is done on the foundation of a few assumptions namely (1) the buyer company is practicing proactive environmental strategy and hence suppliers will be assessed based on both quantitative and qualitative criteria, which will be achieved by utilizing crisp and fuzzy AD approach respectively and (2) all the suppliers being considered in this study have fulfilled legal requirements (e.g. emission level of hazardous gas). Using 'S' to signify supply chain consideration, the design ranges (what the buyer company wants) used for this study are listed as follows:

- $FR_{S,1}$ = Total pollutant costs (PC) should be minimized with the acceptable limit of +25%
- $FR_{S,2}$ = Total improvement costs (IC) should be maximized with the acceptable limit of -25%
- $FR_{S,3}$ = All sub-criteria of management competencies (MC) must be over 5 (5,20,20)
- $FR_{S,4}$ = All sub-criteria of green image (GI) must be over 5 (5,20,20)
- $FR_{S,5}$ = All sub-criteria of design for environment (DE) must be over 5 (5,20,20)
- $FR_{S,7}$ = All sub-criteria of environmental management (EM) systems must be over 5 (5,20,20)
- $FR_{S,8}$ = All sub-criteria of environmental competencies (EC) must be over 5 (5,20,20)

A list of suppliers (given in Table 1) are to be assessed quantitatively based on their pollutant costs (expenditure related to pollution and energy consumption) and improvement costs

(investment in improving environmental performance). Supplier(s) deemed to be satisfactory in this stage shall be evaluated further in terms of their qualitative environmental capabilities.

Table 1. Total pollutant costs and total improvement costs recorded for each of the legal suppliers.

Supplier Name	Total Pollutant Costs (USD)	Total Improvement Costs (USD)
Supplier A	1,137,850	2,000,000
Supplier B	1,503,700	1,900,000
Supplier C	1,018,000	1,630,000
Supplier D	1,877,000	1,370,000
Supplier E	968,900	1,435,650
Supplier F	1,145,000	1,837,500
Supplier G	1,673,800	1,243,600

Using the following equations, information content can be computed for pollutant costs and improvement costs of each supplier's (Suh, 1990).

$$p_i = \frac{Common\ range}{System\ range} \tag{1}$$

$$I_i = log_2\left(\frac{1}{p_i}\right) \tag{2}$$

It can be seen that the pollutant costs and improvement costs are given in individual values instead of a range that consists of upper and lower limit. This makes it impossible to calculate the common range as the system range is not available. To overcome this difficulty, a general value can be employed in calculation to serve as the lower limit or upper limit of system range. For instance, zero can be used as a common lower limit for all suppliers when obtaining the system range of improvement costs of each supplier.

As for pollutant costs, the value of (maximum pollutant costs + x %) is utilized as the common upper limit of system range for all suppliers, where x can be any positive integer. In this case, $x = 20$ is used. The resulted information content will be affected by the value of x but the ranking of suppliers (according to information content) will remain unchanged since every system range (of each supplier) is using the same reference value as upper limit. Figure 11 and Figure 12 show illustrative examples of computation of common ranges for pollutant costs and improvement costs respectively using the recorded costs of Supplier F from Table 1. Note that common ranges are crosshatched in the figures.
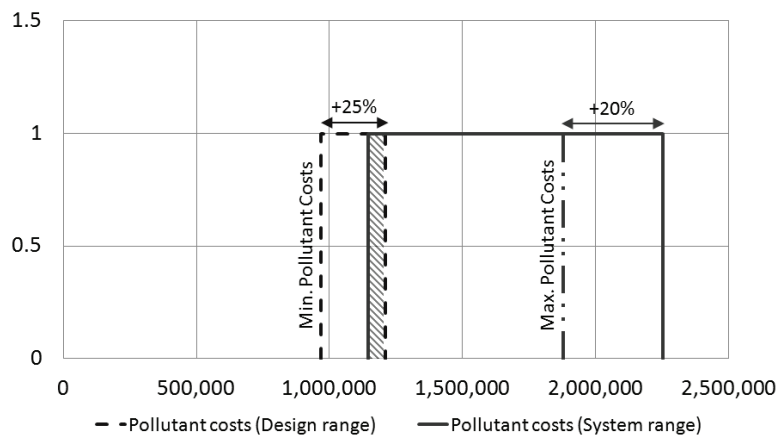
Figure 11. Pollutant costs of Supplier F: Crosshatched area denotes common range.
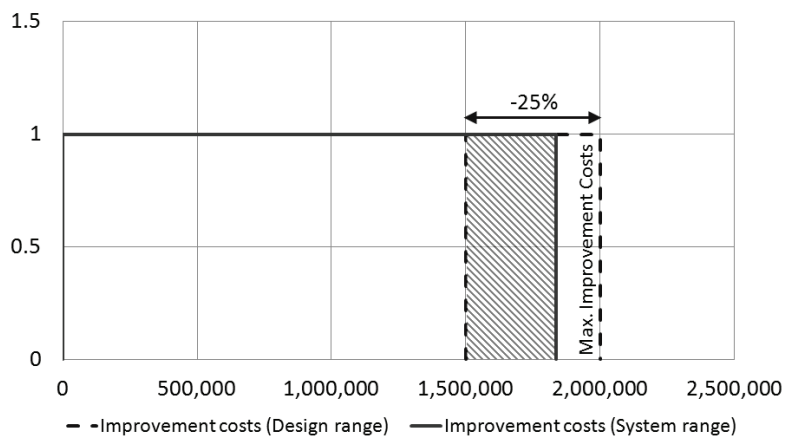
Figure 12. Improvement costs of Supplier F: Crosshatched area denotes common range.

With design range and system ranges defined as such, information content of each alternative supplier is calculated and tabulated in Table 2. Asterisks (*) indicate suppliers qualified for further assessment based on qualitative criteria.

Table 2. Information contents: Suppliers' quantitative environmental capability.

Supplier Name	Pollutant Costs	Improvement Costs	Sum
Supplier A	3.927	2.000	5.927*
Supplier B	Infinite	2.248	Infinite
Supplier C	2.676	3.648	6.324*
Supplier D	Infinite	Infinite	Infinite
Supplier E	2.406	Infinite	Infinite
Supplier F	4.066	2.445	6.511*
Supplier G	Infinite	Infinite	Infinite

The quantitative evaluation (based on pollutant and improvement costs) shows that Suppliers A, C and F are qualified for further evaluation in terms of qualitative environmental capability by considering the criteria weight given in Table 3. Table 4 shows the performance values of each of these categories for each supplier as determined by the buyer company in response to a series of questions.

Table 3. Weight used for each category of environmental criteria.

	Management Competencies	'Green Image'	Design for Environment	Environmental Management Systems	Environmental Competencies
Weight	0.2	0.1	0.2	0.3	0.2

Unlike the previous part of performance analysis, fuzzy axiomatic design approach is applied at this stage since it involves linguistic terms which can be expressed in the form of triangular fuzzy number (TFN, see Figure 13). The notation of TFN and information content are formulated by Equation (3) and Equation (4) respectively. In this case, the common area is the intersection between TFNs of design range and system range as illustrated in Figure 14. Equation (5) is employed to incorporate criterion weight into the analysis. I_{ij} denotes information content of the alternative i for the criterion j; w_j represents the weight of the criterion j; p_{ij} symbolizes the probability of achieving the functional requirement FR_j (criterion j) for the alternative i. By applying Equation (3), Equation (4) and Equation (5), qualitative data can be translated into quantifiable values (weighted information content) to facilitate supplier selection process (Kulak and Kahraman, 2005).

$$\mu(x) = \begin{cases} \dfrac{x-c}{a-c}, & c \leq x \leq a \\ \dfrac{b-x}{b-a}, & a \leq x \leq b \\ 0, & otherwise \end{cases} \tag{3}$$

$$I_i = log_2\left(\frac{TFN\ of\ system\ range}{common\ area}\right) \tag{4}$$

$$I_{ij} = \begin{cases} \left[log_2\left(\dfrac{1}{p_{ij}}\right)\right]^{1/w_j}, & 0 \leq I_{ij} < 1 \\ \left[log_2\left(\dfrac{1}{p_{ij}}\right)\right]^{w_j}, & I_{ij} > 1 \\ w_j, & I_{ij} = 1 \end{cases} \tag{5}$$
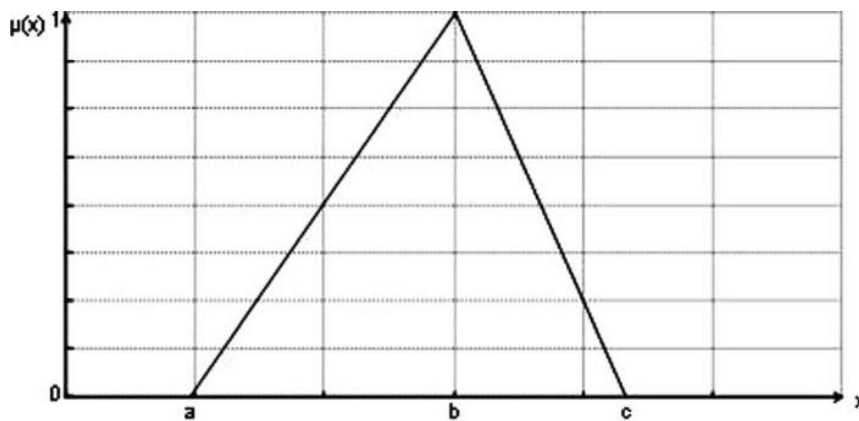
Figure 13. Triangular fuzzy number (Kulak *et al.*, 2010).
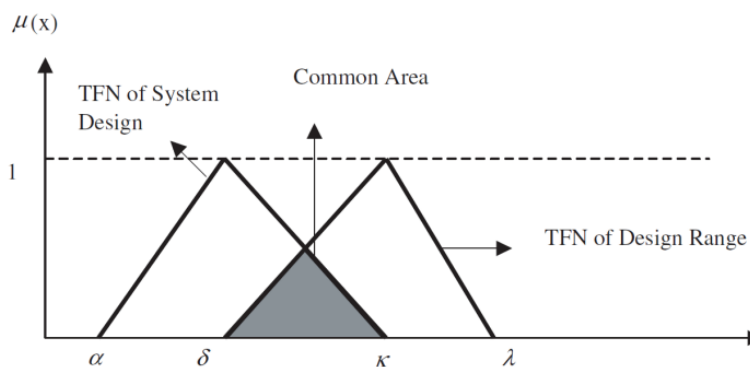
Figure 14. The common area of system and design ranges (Kulak and Kahraman, 2005).

As shown in Figure 15, the buyer company subjectively evaluates the alternatives with the linguistic term "poor" if these criteria are assigned a score of (0, 0, 6) over 20; "fair" with a score of (4, 7, 10) over 20; "good" with a score of (8, 11, 14) over 20; "very good" with a score of (12, 15, 18) over 20; "excellent" with a score of (16, 20, 20) over 20 (Kulak and Kahraman, 2005). With the system range determined, alongside with design ranges given in early part of this section, weighted information contents of each supplier for various criteria can be generated (see Table 5). Unit index of each criterion are calculated by dividing the total information contents in Table 5 by the number of sub-criteria of each main criterion. This step is essential because each criterion consists of different numbers of sub-criteria which may affect the sum of information content (Kulak *et al.*, 2005). Calculated unit indexes are shown in Table 6. By having the smallest sum of unit indexes, Supplier A is deemed as the most eligible green supplier, followed by Supplier C and F respectively.
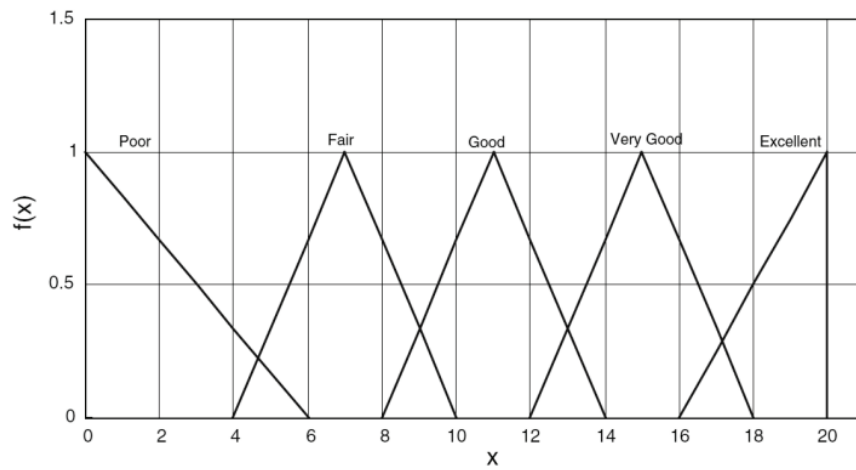
Figure 15. System range: TFNs for intangible factors (Kulak and Kahraman, 2005).

Table 4. Evaluation results presented by procurement team in respect of qualitative factors.

	Management Competencies				'Green Image'			Design for Environment					Environmental Management Systems				Environmental Competencies			
	Senior Management Support	Environment Partners	Training	Information Exchange	Customer's Purchasing Retention	Green Market Share	Stakeholders Relationship	Recycle	Reuse	Remanufacture	Disassembly	Disposal	Environmental Policies	Environmental Planning	Implement and Operation	ISO 14001 Certification	Clean technology availability	Use of environmental friendly material	Pollution reduction capability	Returns handling capability
Supplier A	P	F	F	P	P	E	V	G	E	V	G	F	E	G	V	E	G	V	F	F
Supplier C	V	V	E	V	G	F	P	P	G	F	E	V	F	P	G	V	V	F	F	G
Supplier F	G	F	G	E	F	P	V	G	F	P	F	G	G	V	F	F	P	F	P	G

P = Poor, F = Fair, G = Good, V = Very Good, E = Excellent

Table 5. The weighted results of Suh's information content for alternative suppliers.

	Management Competencies				'Green Image'			Design for Environment					Environmental Management Systems				Environmental Competencies			
	Senior Management Support	Environment Partners	Training	Information Exchange	Customer's Purchasing Retention	Green Market Share	Stakeholders Relationship	Recycle	Reuse	Remanufacture	Disassembly	Disposal	Environmental Policies	Environmental Planning	Implement and Operation	ISO 14001 Certification	Clean technology availability	Use of environmental friendly material	Pollution reduction capability	Returns handling capability
Supplier A	1.475	1.161	1.161	1.475	1.214	0.000	0.000	0.143	0.000	0.000	0.143	1.161	0.000	0.274	0.003	0.000	0.143	0.000	0.143	1.161
Supplier C	0.000	0.000	0.000	0.000	0.021	1.078	1.214	1.475	0.143	1.161	0.000	0.000	1.251	1.791	0.274	0.003	0.000	1.161	1.161	0.143
Supplier F	0.143	1.161	0.143	0.000	1.078	1.214	0.000	0.143	1.161	1.475	1.161	0.143	0.274	0.003	1.251	1.251	1.475	1.161	1.475	0.143

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Table 6. Unit Indexes for weighted information contents.

Supplier Name	Management Competencies	'Green Image'	Design for Environment	Environmental Management Systems	Environmental Competencies	Total Unit Index
Supplier A	1.318	0.405	0.290	0.069	0.362	2.444
Supplier C	0.000	0.771	0.556	0.830	0.616	2.773
Supplier F	0.362	0.764	0.817	0.695	1.064	3.701

3. Optimization for Sustainable Machining

Machining process is required to manufacture the closed-back housing (e.g. to provide an opening through which a display screen may be viewed). To make a manufacturing process sustainable, the following six factors (together with their desired levels) as shown in Table 7 are generally regarded as significant (Wanigarathne *et al*., 2004). These six factors can be divided into two broad categories i.e. sustainability factors for safety, health and environment (S_{SHE}) and operational sustainability factors (S_{OP}) which comprises machining costs, energy consumption and waste management (Jayal *et al*., 2010).

The optimization problem of sustainable manufacturing involves parameters (according to categories, together with desired levels) as shown in Table 8 (Jawahir *et al*., 2006).

Table 7. Measurable sustainability factors in machining processes and their desired levels (Wanigarathne *et al*., 2004).

Measurement Factor	Desired level
Energy consumption	Minimum
Environmental friendliness	Maximum
Machining costs	Minimum
Operational safety	Maximum
Personnel health	Maximum
Waste reduction	Maximum

Table 8. Parameters involved in optimization problem.

Category	Parameter	Desired Level
Cutting Condition	Cutting speed (V)	$V_{min} \leq V \leq V_{max}$
	Feed rate (f)	$f_{min} \leq f \leq f_{max}$
	Depth of cut (d)	$d_{min} \leq d \leq d_{max}$
Sustainability	Machining cost (MC)	$MC \leq MC'$
	Energy consumption (EC)	$EC \leq EC'$
	Waste reduction (WR)	$WR \geq WR'$
	Personnel health (PH)	$PH \geq PH'$
	Operational safety (OS)	$OS \geq OS'$
	Environmental friendliness (EF)	$EF \geq EF'$
Functional/ Performance	Surface roughness (R_a)	$R_a \leq R'_a$
	Cutting force (F)	$F \leq F'$
	Tool life (T)	$T \geq T'$
	Material removal rate (M_R)	$M_R \geq M'_R$
	Chip breakability (CB)	$CB \geq CB'$

To provide a simpler visualization on the cause-effect relationship, the mathematical model can be derived into the following FRs to be satisfied by an optimized manufacturing system in general and a set of DPs as the corresponding solutions to fulfill the FRs ('M' denotes manufacturing consideration):

- $FR_{M,1}$ = To maintain cutting condition within manageable range
- $FR_{M,2}$ = To attain satisfactory machining performance
- $FR_{M,3}$ = To achieve process sustainability at desired level

- $DP_{M,1}$ = Parameters of cutting condition must be set within constraints
- $DP_{M,2}$ = Employ adequate cooling method
- $DP_{M,3}$ = All sustainability factors to satisfy respective requirement

The relationship between the FRs and DPs can be stated in terms of design matrix (see Figure 16). Note that both $DP_{M,1}$ and $DP_{M,2}$ have to be considered in order to achieve $FR_{M,2}$. Previous research has proven that machining performance (e.g. surface roughness and material removal rate) differs with cooling methods and cutting conditions utilized for the machining process (Jawahir *et al*., 2006; Puvasec *et al*., 2010a). Besides that, it can be seen that all three DPs are involved when it comes to satisfying $FR_{M,3}$. This is due to the dependency of sustainability parameters on cutting condition and cooling method set by the user as experiments have shown that machining cost and energy consumption vary with cutting speed and coolant delivery systems (Pusavec *et al*., 2010b). In this case, the design matrix obtained is a triangular matrix which signifies that the design being considered is a decoupled design. Under this circumstance, with the purpose of satisfying the independence axiom, DPs should be adjusted in a particular sequence. $DP_{M,1}$ should be varied first to meet $FR_{M,1}$, followed by adjusting $DP_{M,2}$ to fulfill $FR_{M,2}$. Lastly, $DP_{M,3}$ can be determined to achieve $FR_{M,3}$ (Suh, 1990). In other words, parameters of cutting condition such as cutting speed and feed rate must first be decided before proceeding to select cooling method to fulfill required machining performance. Finally, for each selected cooling method (with given cutting conditions), sustainability parameters can be analyzed and compared against the requirement.

	$DP_{M,1}$	$DP_{M,2}$	$DP_{M,3}$
$FR_{M,1}$	X	0	0
$FR_{M,2}$	X	X	0
$FR_{M,3}$	X	X	X

Figure 16. Design matrix for optimization problem in sustainable machining.

3.1. Determining the Cutting Condition

For this optimization problem, machining parameters employed are presented in Table 9. These parameters are ambiguous and will be used for demonstration purpose only. Note that it is possible to use unique sets of parameters for different cooling methods. However, this case study assumes standardized parameters for all processes for simplicity's sake.

Table 9. Cutting condition being considered.

Parameter	Value
Cutting Speed, V (m/min)	30
Feed rate, f (mm)	0.25
Depth of cut, d (mm)	1.2

3.2. Selection of Adequate Cooling Method

Cooling method can be selected from a series of available processes in order to achieve necessary machining performance ($FR_{M,2}$). This study assumes that all three processes (Process I, Process II and Process III) are capable of meeting the required machining performance with cutting conditions given in the last section and shall proceed for further analysis.

3.3. Comparison of Sustainability Performance against Desired Level

As mentioned in earlier section, $FR_{M,3}$ dictates the requirement to achieve process sustainability at desired level. This FR can be further decomposed to specify requirement for each of the sustainability factors. An example of decomposed $FR_{M,3}$ is shown as follows:

- $FR_{M,31}$ = Machining cost per part must be in the range of 0 to \$1.85
- $FR_{M,32}$ = Energy consumption per part must be in the range of 0 to 0.15 kWh
- $FR_{M,33}$ = Part cleaning cost must be in the range of 0 to \$0.08
- $FR_{M,34}$ = Environmental friendliness must be at least 5 (5,20,20)
- $FR_{M,35}$ = Operational safety must be at least 5 (5,20,20)
- $FR_{M,36}$ = Personnel health must be at least 5 (5,20,20)

The selection of cutting condition with cutting speed of 30m/min, feed rate of 0.25mm, and depth of cut of 1.2mm yields the corresponding machining costs (include cutting tool and cooling/lubrication fluid (CLF) costs), energy consumption rate and waste processing cost as shown in Table 10. Note that this information should be collected empirically. Table 10 also shows sustainability performances such as environmental friendliness and personnel health

which are graded qualitatively. The information axiom can be used to construct a hybrid model that facilitates the analysis of sustainability performance.

Table 10. Sustainability performance corresponding to cutting condition of $V = 30$m/min, $d = 1.2$mm, and $f = 0.25$mm.

Machining Process	Machining Costs (USD/part)	Energy Consumption (kWh/part)	Waste Management (USD/part)	Environmental Friendliness	Operational Safety	Personnel Health
Process I	1.811	0.148	0.078	Poor	Poor	Poor
Process II	2.016	0.147	0.004	Excellent	Excellent	Excellent
Process III	1.794	0.202	0.074	Fair	Good	Good

For operational sustainability factors (S_{OP}) such as machining costs, energy consumption and waste management cost, crisp AD approach can be used to translate the evaluation results into performance scores in terms of information content using Equation (1) and Equation (2). Similar to previous section, evaluation results for S_{OP} given in Table 10 are presented in individual values rather than a specific range bounded by lower and upper limits. To address this issue, an acceptance threshold can be introduced. It can be deemed as maximum allowable variation for each parameter and serves as an imaginary upper limit for each system range. An illustrative example is given in Figure 17 to show the computation of common range for machining costs of Process III. In the figure, the intersection between design range and system range is crosshatched. Note that the upper limit of system range is obtained by introducing a 20% variation in machining costs.
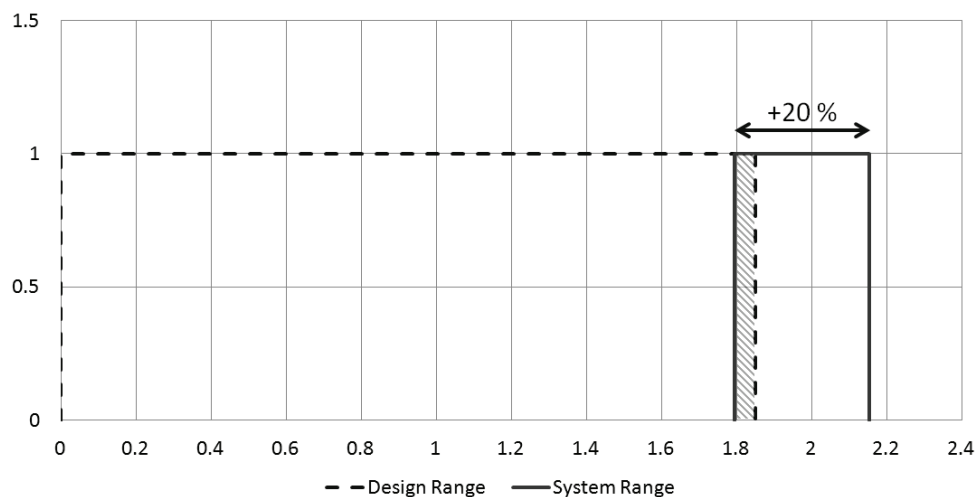
Figure 17. Machining costs of Process III: intersection of design range and system range.

In this scenario, fuzzy AD approach is particularly helpful for analyzing sustainability performance for environmental friendliness, personnel health and operational safety (S_{SHE}) by

converting qualitative terms like "poor", "fair" and "good" into information content. Using the system range depicted in Figure 15, coupled with Equation (3) and Equation (4), weighted information content can be computed for each alternative process based on FRs determined earlier in this section.

Equal weight factor of 0.5 is used for both S_{OP} and S_{SHE} in this case. With the application of Equation (5), weighted information contents for all criteria can be tabulated as in Table 11. Subsequently, unit indexes for S_{OP} and S_{SHE} are calculated and shown in Table 12. From Table 12, it is indicated that Process I is the only viable process that satisfies all required sustainability performance. Both Process II and Process III have infinite information content due to high energy consumption and unsatisfying machining costs respectively. In the event when all processes have infinite unit index (no sustainable process), the procedure mentioned in sections 3.1 and 3.2 should be repeated (i.e. reselecting cutting conditions and cooling method).

Table 11. Weighted information contents.

Machining Process	Machining Costs	Energy Consumption	Waste Management	Environmental Friendliness	Operational Safety	Personnel Health
Process I	1.7931	1.9717	1.7215	2.6415	2.6415	2.6415
Process II	Infinite	1.8146	0.0000	0.0000	0.0000	0.0000
Process III	1.6370	Infinite	1.1413	1.4529	0.4598	0.4598

Table 12: Unit indexes for weighted information content (* denotes viable process that satisfies all FRs with minimum information content).

Manufacturing Process	Operational Sustainability	Safety, Health and Environment	Sum
Process I	1.8288	2.6415	4.4702*
Process II	Infinite	0.0000	Infinite
Process III	Infinite	0.7909	Infinite

3.4. Summary

This section summarizes the decisions made in previous sections (with the help of axiomatic design) concerning design for EOL management, green supplier selection (supply chain consideration) and sustainable manufacturing for development of a closed-back housing.

From EOL standpoint, Embodiment 2 which enables simpler recovery procedure and thus increases the recovery potential is used as predominant product architecture. When it comes to green supplier selection, Supplier A is the most eligible green supplier followed by

Supplier C and Supplier F respectively. This information can be used by the procurement team when sourcing for raw material of closed-back housing. As for sustainable manufacturing, an optimization procedure has been carried out in previous section to determine the rightful machining process to be adopted for the manufacturing of the closed-back housing. By considering the cutting conditions, sustainability (S_{OP} and S_{SHE}), and machining performance, Process I is deemed to be the most capable process to be employed.

DISCUSSION

This section discusses the accuracy and reliability of results obtained from the case studies presented in the last section. An evaluation is covered in the first part of the discussion to compare the recovery potential between different embodiments of closed-back media player housing. Cost breakdown for recovery operations is tabulated to reveal the potential saving achievable by implementing the correct product structure that enables streamlined recovery process. Apart from that, results obtained from performance analysis on alternative suppliers are verified in second part of the discussion by reanalyzing the suppliers' qualitative performance using another well-established method. The two sets of results are then compared to ensure that two different approaches yield the identical outcome. In the final part of the discussion section, an example is presented to demonstrate the iteration of optimization procedure in case the selected machining process is unable to fulfill required sustainability level.

1. Design Evaluation using Transition Matrix

The beginning part of the previous section shows several embodiments of media player featuring a closed-back housing and transparent window. To compare the product architectures and to scrutinize the variation in recovery potential caused by the architectural differences, the respective recovery operations can be represented in the form of transition matrix (Kwak and Kim, 2010).

As shown in Figure 8, Embodiment 1 and Embodiment 3 require similar disassembly procedure to remove a defective transparent window from the closed-back housing whereby screws have to be unfastened after top and bottom bezels are pried open. Embodiment 2 on the other hand, requires only a prying action to remove defective transparent window after heating the adhesive. The disassembly and reassembly procedures are shown in the following transition matrices alongside the associated costs (see Figure 18 and Figure 19). Considering the first column of Figure 18, the disassembly process consumes an ABCD* assembly and produces two individual parts of B and ACD*. Note that asterisks in the matrices denote defective parts.

Operations States	1	2	3	4	5	6	7
	Disassembly			Spare	Reassembly		
ABCD*	-1	0	0	0	0	0	0
ABCD	0	0	0	0	0	0	1
ACD*	1	-1	0	0	0	0	0
ACD	0	0	0	0	0	1	-1
AD*	0	1	-1	0	0	0	0
AD	0	0	0	0	1	-1	0
A	0	0	1	0	-1	0	0
B	1	0	0	0	0	0	-1
C	0	1	0	0	0	-1	0
D*	0	0	1	0	0	0	0
D	0	0	0	1	-1	0	0

Operations	1	2	3	4	5	6	7
Cost (USD)	0.10	0.10	0.10	0.80	0.10	0.10	0.10

Legend:
A = Closed-back housing   B= Bezels   C = Screws   D = Transparent window
D* = Defective transparent window

Figure 18. Transition matrix of Embodiment 1 and Embodiment 3 and the associated operation costs.

Operations States	1	2	3
	Disassembly	Spare	Reassembly
AD*	-1	0	0
AD	0	0	1
A	1	0	-1
D*	1	0	0
D	0	1	-1

Operations	1	2	3
Cost (USD)	0.40	0.80	0.10

Legend:
A = Closed-back housing   D = Transparent window
D* = Defective transparent window

Figure 19. Transition matrix of Embodiment 2 and the associated operation costs.

Table 13 compiles the total recovery costs required to replace defective transparent windows for 10,000 returned units as part of product refurbishment process. A potential cost-saving of $1,000 can be achieved when Embodiment 2 is employed as the predominant product architecture. This cost-saving is likely to lead to a profit surplus and it can be attained simply by adopting architecture that favors product recovery. As demonstrated previously, such decision-making process can be facilitated by AD principles and it is crucial to include recovery-related FRs during the problem definition stage.

Table 13. Comparison of recovery costs between different embodiments (considering refurbishment of 10,000 units).

Cost of Recovery Operations (USD)	Embodiment 1 & Embodiment 3	Embodiment 2
Disassembly	3000	4000
Part replacement	8000	8000
Reassembly	3000	1000
Total cost (USD)	14000	13000

2. Verification of Results: Green Supplier Selection

In terms of quantitative capabilities, it can be observed from Table 2 that AD approach (information axiom) is effective at ruling out suppliers with unsatisfying pollutant and/or improvement costs. For instance, Supplier B whose pollutant costs exceed the predetermined limit is not qualified for further assessment.

To verify the qualitative results obtained using fuzzy AD approach, the analysis of data (shown in Table 4) is repeated by utilizing multi-attribute analysis technique (MAA) (Holt *et al.*, 1995). MAA has been used widely for decision-making purposes. Historically, it has been employed by Holt *et al.* (1995) to aid the selection of construction contractor using a computer spreadsheet approach. Following Holt et al.'s research, Humphreys *et al.* (2003) proposed a decision support system that can be used to analyze suppliers' environmental capability. A zero-to-four scale is used for this analysis whereby scores are given to each grade according to Table 14. Analysis results are shown in Table 15 and Table 16. Note that all the environmental criteria have equal importance, in other words, the analysis is unweighted. The MAA approach is repeated by involving criteria weights as shown in Table 3. When applying the weights into data in Table 16, a set of weighted scores as tabulated in Table 17 can be obtained. Likewise, the results obtained in Table 17 tallies with the results computed using fuzzy AD approach (Table 6) as Supplier A is indicated as the most eligible green supplier followed by Supplier C and Supplier F.

Table 14. Multi-criteria analysis: Grades and corresponding scores.

Grade	Poor	Fair	Good	Very Good	Excellent
Score	0	1	2	3	4

3. Sustainable Machining: Reiteration for Enhanced Sustainability

In the presented case study, Process I is selected as optimized solution that fulfills all sustainability FRs. If analysis results show infinite unit index for all processes, the

optimization procedure can be reiterated. In other words, cutting conditions can be altered to yield different sets of corresponding sustainability performance for all cooling methods (e.g. machining costs and energy consumption). Again, the new set of sustainability performance has to be compared against the desired level to identify the viable process. As an example, cutting speed can be altered from 30m/min to 60m/min which in turn varies the machining costs and energy consumption (with other machining parameters unchanged and corresponding machining performance unaffected). Table 18 shows the revised sustainability performance when cutting speed of 60m/min is used. This set of sustainability performances can eventually be converted to unit indexes when procedure stated in the case study section is repeated (see Table 19). It can be seen that both Process II and Process III are viable processes as they fulfill the required sustainability performance. Nevertheless, Process II should be selected since it has the smallest information content.

Table 15. MAA Technique: Qualitative environmental analysis on suppliers (Unweighted).

	Management Competencies				'Green Image'			Design for Environment					Environmental Management Systems				Environmental Competencies			
	Senior Management Support	Environment Partners	Training	Information Exchange	Customer's Purchasing Retention	Green Market Share	Stakeholders Relationship	Recycle	Reuse	Remanufacture	Disassembly	Disposal	Environmental Policies	Environmental Planning	Implement and Operation	ISO 14001 Certification	Clean technology availability	Use of environmental friendly material	Pollution reduction capability	Returns handling capability
Supplier A	0	1	1	0	0	4	3	2	4	3	2	1	4	2	3	4	2	3	2	1
Supplier C	3	3	4	3	2	1	0	0	2	1	4	3	1	0	2	3	3	1	1	2
Supplier F	2	1	2	4	1	0	3	2	1	0	1	2	2	3	1	1	0	1	0	2

Table 16. Average score for each supplier (Unweighted).

	Management Competencies		'Green Image'		Design for Environment		Environmental Management Systems		Environmental Competencies		Average Score (%)
	Sum	Score (%)	Sum	Score (%)	Sum	Score (%)	Sum	Score (%)	Sum	Score (%)	
Supplier A	2	12.50	7	58.33	12	60.00	13	81.25	8	50.00	52.42
Supplier C	13	81.25	3	25.00	10	50.00	6	37.50	7	43.75	47.50
Supplier F	9	56.25	4	33.33	6	30.00	7	43.75	3	18.75	36.42

Table 17. Sum of weighted score for each competing supplier (highest score signifies the most eligible supplier).

	Management Competencies	'Green Image'	Design for Environment	Environmental Management Systems	Environmental Competencies	Sum of Weighted Score (%)
Supplier A	2.500	5.833	12.000	24.375	10.000	54.708
Supplier C	16.250	2.500	10.000	11.250	8.750	48.750
Supplier F	11.250	3.333	6.000	13.125	3.750	37.458

Table 18. Sustainability performance corresponding to cutting condition of $V = 60$m/min, $d = 1.2$mm, and $f = 0.25$mm.

Machining Process	Machining Costs (USD/part)	Energy Consumption (kWh/part)	Waste Management (USD/part)	Environmental Friendliness	Operational Safety	Personnel Health
Process I	2.049	0.082	0.078	Poor	Poor	Poor
Process II	1.461	0.077	0.004	Excellent	Excellent	Excellent
Process III	1.319	0.105	0.074	Fair	Good	Good

Table 19. Unit indexes for weighted information content (* denotes viable process that satisfies all FRs with minimum information content).

Manufacturing Process	Operational Sustainability	Safety, Health and Environment	Sum
Process I	Infinite	2.6415	Infinite
Process II	0.0000	0.0000	0.0000*
Process III	0.3804	0.7909	1.1713

CONCLUSION

Firms/companies are changing their ways of designing and developing new products owing to mounting environmental issues, public pressure and stricter regulations. To properly address issues concerning sustainable product realization, EOL management, manufacturing considerations and supply chain modeling have to be taken into account during design stage.

Product design is deemed as the utmost important factor that contributes rewarding EOL management while green supplier selection can be regarded as the most significant corporate function for integrating environmental factors into supply chain. Process optimization is unavoidable when dealing with sustainable manufacturing. Optimal combinations of operating parameters can be obtained by means of optimization procedure and it allows trade-off among performance and sustainability measures to be made.

A case study is presented in this paper to illustrate the application of AD principles to address issues regarding design for EOL management, green supplier selection and manufacturing system optimization with the aim of developing an environmentally friendly electronic device. A closed-back housing for a media player is used in this case study as an illustrative example to provide better understanding of the overall procedure. In the beginning part of the case study, AD is used to guide the product design process so that enhanced product architecture (in terms of recovery potential, considering a scenario of replacing defective window) is produced. Subsequently, AD principles are applied to the process of selecting raw material

supplier based on their environmental capabilities. Next, an optimization procedure is conducted with the help of AD principles to identify the most competent manufacturing (machining) process that satisfies the cutting condition constraints, desired level of sustainability (S_{OP} and S_{SHE}), and performance requirements.

At the end of the case study, it is found that Embodiment 2 should be implemented as the predominant design of closed-back housing as it allows simple recovery process in the event of replacing defective transparent window. Supplier A is found to be the most eligible raw material supplier as the supplier meets the quantitative and qualitative criteria with the smallest information content. It is also indicated that Process I should be used to machine the closed-back housing when the cutting conditions are set as in Table 9. The outcome of the case study is discussed and verified in subsequent section.

The recovery operations of different embodiments are represented in the form of transition matrices to allow straightforward comparison of procedures involved and incurred costs. It is clear that transparent window on Embodiment 2 can be replaced with lesser steps and lower recovery costs. This cost-saving will in turn contribute to the product developer's profit and it shows that application of AD can produce product architecture that facilitates recovery operations when refurbishment-related requirements are involved during problem definition stage.

Apart from that, the selection of green supplier is repeated using the MAA technique which yields identical result that ranks Supplier A as the most eligible green supplier. This proves that fuzzy AD approach is comparable to MAA technique and is applicable as a decision support system in the area of qualitative analysis for green supplier selection.

Other than supplier selection, the selection of optimized machining process is also reiterated by applying different cutting conditions (cutting speed in particular). This change in turn leads to a different set of S_{OP} performance (empirical data) which ultimately varies the final selection. It can be concluded that an optimized manufacturing solution can be obtained by following a step-by-step procedure namely (1) setting the cutting condition, (2) selecting adequate cooling method and (3) analysis of sustainability performance. Subsequently, analysis results may be reviewed and accepted if desired level of sustainability is attained. Should the analysis results indicate no viable process, the optimization procedure can be iterated to achieve satisfying sustainability.

A sustainable product development framework (see Figure 20) is proposed by rearranging the FRs and DPs used throughout the case study in hierarchical manner. Note that the chart is constructed by using machining as example of major manufacturing process. One should be aware that this framework is applicable to but not limited to products manufactured by means of machining.
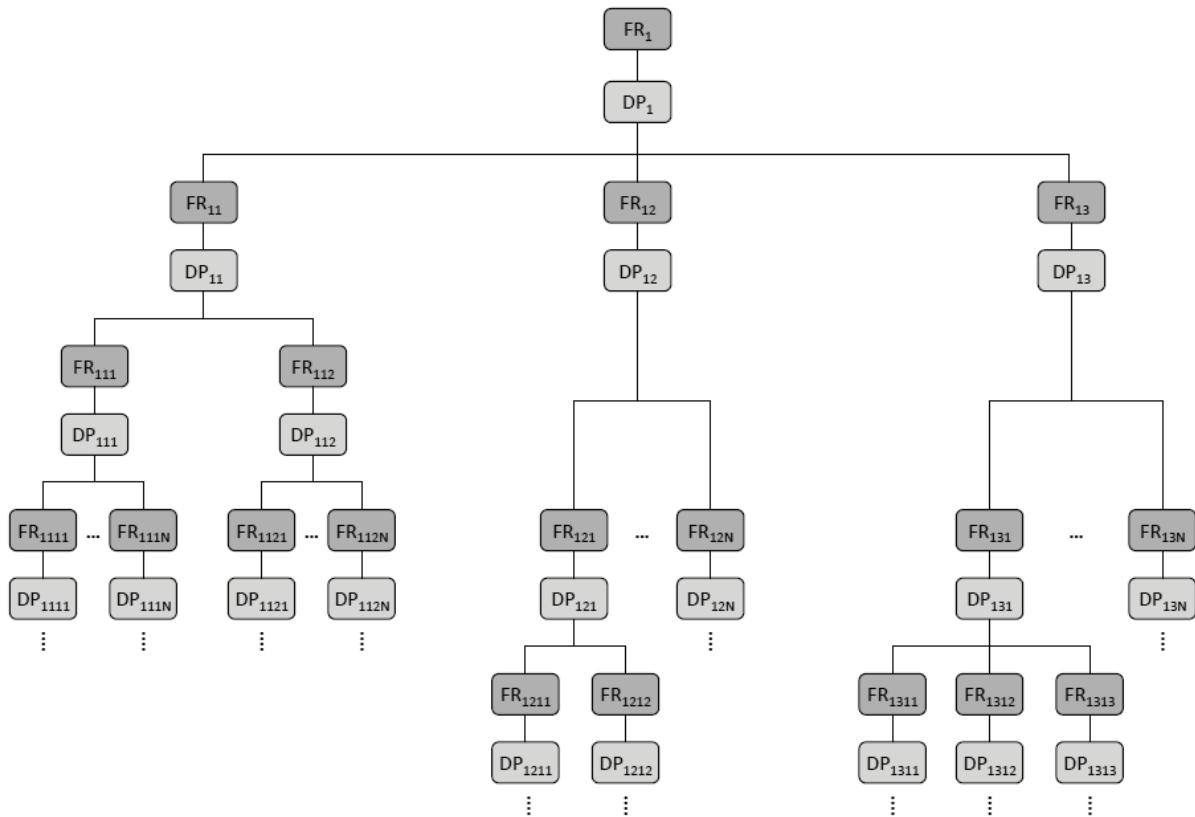
Figure 20. Hierarchy of FRs and DPs to achieve sustainable product development.

The chart serves as a general guideline for FRs and DPs related to sustainable product development and therefore, the hierarchy can be expanded by further decomposing the FRs to involve more detailed, assembly-specific requirements. By performing the procedure shown in presented case study, with the aid of the set of proposed FR and DP hierarchy, an environmentally friendly product that considers the recovery procedure, green supply chain and sustainable manufacturing can potentially be developed. FRs and DPs being considered in Figure 20 are listed as follows:

- FR_1 = To achieve sustainable product development
- FR_{11} = Functional product that enables effective product recovery
- FR_{12} = Sustainable supply chain management
- FR_{13} = Environmentally conscious manufacturing
- FR_{111} = Media player to have small-sized body and simplistic appearance (example)
- FR_{112} = Product to have high recovery potential
- FR_{121} = To purchase raw material for closed-back housing from green supplier (example)
- FR_{131} = To adopt optimized manufacturing solution for closed-back housing (example)
- FR_{1111} = Closed-back housing to provide protection for internal components (example)
- FR_{1121} = Easier or more economical disassembly of the parts in the product (example)

- FR_{1211} = Supplier(s) to have adequate qualitative environmental capability
- FR_{1212} = Supplier(s) to show satisfactory qualitative environmental capability
- FR_{1311} = Manageable cutting conditions
- FR_{1312} = Satisfactory manufacturing performance
- FR_{1313} = Desired sustainability performance

- DP_1 = To consider EOL management, green supply chain and sustainable manufacturing during design stage
- DP_{11} = Design for EOL management
- DP_{12} = Purchase from green supplier(s)
- DP_{13} = Adopt optimized manufacturing solution
- DP_{111} = To use closed-back housing with overall dimensions of 50mm × 30mm × 7mm and button-less control (example)
- DP_{112} = Fewer parts (or less material volume) in product and more economical replacement of parts in discarded product (example)
- DP_{121} = Raw material supplier to be assessed based on qualitative and quantitative environmental criteria (example)
- DP_{131} = Cutting conditions, sustainability and machining performance to be considered during optimization (example)
- DP_{1111} = Maintain substantial housing wall thickness (example)
- DP_{1121} = Defective window to be replaced by minimal recovery operations (example)
- DP_{1211} = Supplier(s) to meet pollutant and improvement costs requirement
- DP_{1212} = Supplier(s) to have acceptable capabilities in terms of management competencies, green image, design for environment, environmental management systems and environmental competencies
- DP_{1311} = Cutting condition to be set within realistic/achievable range
- DP_{1312} = Employ adequate cooling method
- DP_{1313} = All sustainability factors to satisfy respective requirement

It is also advisable to delegate the tasks to responsible parties according to their roles in the firm/company. For example, design for EOL management can be assigned to the designers while the manufacturing engineers take over the selection of optimized manufacturing process. At the same time, the procurement team should assume the responsibility of selecting the right supplier based on environmental criteria. Most importantly, these decisions must be made during the early design stage as they tend to affect other life cycle stages in terms of environmental impacts (Rebitzer, 2002). If the tasks are delegated to separate parties, it is crucial for all parties to maintain constant communication throughout the entire development process to ensure swift exchange of information.

ACKNOWLEDGEMENT

REFERENCES

1. Ayres, R. U. and Ayres, L. W. (2002), *A Handbook of Industrial Ecology*, Edward Elgar, Northampton.
2. BEA (2008), "Annual Industry Accounts", available at: http://www.bea.gov/about/pdf/IED_Annual.pdf (accessed 20/09/2010).
3. Chen, K. Z. (2001), "Development of Integrated Design for Disassembly and Recycling in Concurrent Engineering", *Integrated Manufacturing Systems*, Vol. 12 No. 1, pp. 67 – 79.
4. Chertow, M. R. (2000), "The IPAT Equation and Its Variants: Changing Views of Technology and Environmental Impact", *J. Ind. Ecol.*, Vol. No. 4, pp. 13-29.
5. Choi, J. K., Nies, L. F. and Ramani, K. (2008), "A framework for the integration of environmental and business aspects toward sustainable product development", *Journal of Engineering Design*, Vol. 19 No. 5, pp. 431-446.
6. Detwiler, B. (2010), "Apple IPod Nano 6th Generation (2010) Teardown", available at: http://www.techrepublic.com/pictures/apple-ipod-nano-6th-generation-2010-teardown/ (accessed 25/08/13).
7. EIA (2006), *2002 Manufacturing Energy Consumption Survey.*
8. Green, K., Morton, B. and New, S. (1998), "Green purchasing and supply policies: do they improve companies' environmental performance?" *Supply Chain Manage*, Vol. 3 No. 2, pp. 89–95.
9. Gutowski, T. (2004), "Design and Manufacturing for the Environment", (Ed.), *Handbook of Mechanical Engineering*, Springer-Verlag, Berlin.
10. Holt, G. D., Olomolaiye, P. O. and Harris, F. C. (1995), "Applying multi-attribute analysis to contractor selection decisions", *European Journal of Purchasing & Supply Management*, Vol. 1 No. 3, pp. 139–148.
11. Humphreys, P. K., Wong, Y. K. and Chan, F. T. S. (2003), "Integrating Environmental Criteria into the Supplier Selection Process", *Journal of Materials Processing Technology*, Vol. 138 No. 1, pp. 349–356.
12. iFixit.com (2006), "iPod Nano 2nd Generation Teardown", available at: http://www.ifixit.com/Teardown/iPod+Nano+2nd+Generation+Teardown/592/1 (accessed 25/08/13).

13. Jawahir, I. S., Wanigarathne, P. C. and Wang, X. (2006), "Product design and manufacturing processes for sustainability", Kutz, M. (Ed.), *Mechanical Engineers' Handbook: Manufacturing and Management*, John Wiley & Sons, pp. 414-443.

14. Jayal, A. D., Badurdeen, F., Jr., O. W. D. and Jawahir, I. S. (2010), "Sustainable manufacturing: Modeling and optimization challenges at the product, process and system levels", *CIRP Journal of Manufacturing Science and Technology*, Vol. 2 No. 3, pp. 144–152.

15. Kulak, O., Durmuşoğlu, M. B. and Kahraman, C. (2005), "Fuzzy multi-attribute equipment selection based on information axiom", *Journal of Materials Processing Technology*, Vol. 169 No. 3, pp. 337–345.

16. Kulak, O. and Kahraman, C. (2005), "Fuzzy multi-attribute selection among transportation companies using axiomatic design and analytic hierarchy process", *Information Sciences*, Vol. 170 No. 2, pp. 191–210.

17. Kulak, O., Cebi, S. and Kahraman, C. (2010), "Applications of axiomatic design principles: A literature review", *Expert Systems with Applications*, Vol. 37 No. 9, pp. 6705-6717.

18. Kwak, M. and Kim, H. M. (2010), "Evaluating End-of-Life Recovery Profit by a Simultaneous Consideration of Product Design and Recovery Network Design", *Journal of Mechanical Design*, Vol. 132 No. 7, pp. 1-17.

19. Leenders, M. R. and Fearon, H. E. (1993), *Purchasing and materials management*, Richard D. Irwin, New York.

20. Miheclic, J. R., Paterson, K. G., Phillips, L. D., Zhang, Q., Watkins, D. W., Barkdoll, B. D., Fuchs, V. J., Fry, L. M., Hokanson, D. R. and Ayres, L. W. (2008), "Educating Engineers in the Sustainable Futures Model With a Global Perspective", *Civil Engineering and Environmental Systems*, Vol. 25 No. 4, pp. 255-263.

21. Min, H. and Galle, W. P. (1997), "Green Purchasing Strategies: Trends and Implications", *International Journal of Purchasing and Materials Management*, Vol. 33 No. 3, pp. 10-17.

22. Min, H. and Galle, W. P. (2001), "Green purchasing practices of US firms." *Int J Oper Prod Manage*, Vol. 21 No. 9/10, pp. 1222–38.

23. Preuss, L. (2001), "In dirty chains? Purchasing and greener manufacturing", *J Bus Ethics*, Vol. 34 No. 3/4, pp. 345–59.

24. Pusavec, F., Kramar, D., Krajnik, P. and Kopac, J. (2010a), "Transitioning to sustainable production – Part I: application on machining technologies", *Journal of Cleaner Production*, Vol. 18 No. 12, pp. 174–184.

25. Pusavec, F., Kramar, D., Krajnik, P. and Kopac, J. (2010b), "Transitioning to sustainable production – Part II: Evaluation of sustainable machining technologies", *Journal of Cleaner Production*, Vol. 18 No. 12, pp. 1211–1221.

26. Ramani, K., Ramanujan, D., Bernstein, W. Z., Zhao, F., Sutherland, J., Handwerker, C. and Choi, J.-K. (2010), "Integrated Sustainable Life Cycle Design: A Review", *Journal of Mechanical Design*, Vol. 132 No. 9.

27. Rebitzer, G. (2002), "Integrating life cycle costing and life cycle assessment for managing costs and environmental impacts in supply chains", S. Seuring, M. G. (Ed.), *Cost management in supply chains*, Physica-Verlag, Heidelberg.

28. Silva, N., Jawahir, I. S., Dillon, O. and Russell, M. (2009), "A New Comprehensive Methodology for the Evaluation of Product Sustainability at the Design and Development Stage of Consumer Electronic Products", *International Journal of Sustainable Manufacturing*, Vol. 1 No. 3, pp. 251-264.

29. Suh, N. P. (1990), *The Principles of Design*, Oxford University Press, New York.

30. Wanigarathne, P. C., Liew, J., Wang, X., O. W. Dillon, J. and Jawahir, I. S. (2004), "Assessment of process sustainability for product manufacture in machining operations", *Proc. Global Conference on Sustainable Product Development and Life Cycle Engineering*, Vol. No. pp. 305–312.

31. Weber, D. J., Moolsintong, P. J. and Zadesky, S. P. (2012), *Media Player with Machined Window Undercut and Transparent Wall Disposed Therein*, US 20120281344A1.

32. Webster, F. J. (1992), "The changing role of marketing in the corporation", *J Market*, Vol. 56 No. 4, pp. 1-17.

33. Williams, A. J., Guinipero, L. C. and Henthorne, T. L. (1994), "The cross-functional imperative: the case of marketing and purchasing", *Int J Purchasing Mater Manage*, Vol. 30 No. 3, pp. 29-33.

CROWDSOURCING UTILIZATION IN INNOVATION MANAGEMENT

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ABSTRACT

Purpose: *Innovation is one of the most important economic drivers in modern businesses. Organizations should be more and more capable in innovation. A market pull innovation lowers the launching costs of new products and services. An organization's management of innovations can benefit from external and internal knowledge. A wide range of industries can utilize crowdsourcing in innovation management. Crowdsourcing imports external and internal knowledge to an organization's innovation management more extensively. This study is focusing on and analyzes the utilization of crowdsourcing in innovation management.*

Design/methodology/approach: *This research is a case study. The research includes product and service industries with the case study organizations operating over a wide range of industry sectors. Empirical data was collected from 14 case study organizations using interviews and a web survey. This research utilizes the four phase innovation management model: search, select, implement, and capture.*

Findings: *Crowdsourcing is utilized in innovation management in a wide range of industry sectors. The study states that crowdsourcing can be a crucial part of innovation management. The research highlights the crowdsourcing types which can be utilized in innovation management. Crowdsourcing utilization in innovation management can support the creation of innovations which have a pull on the markets. From this point of view the crowd is also acting as a marketer for an organization.*

Limitations: *Research is studying crowdsourcing utilization in innovation management in a wide range of industries with a common innovation management model. Innovation management processes in organizations requires more research. Innovations are implemented mainly with projects. Project management requires more research from a crowdsourcing point of view.*

Originality/value: *Based on this study: crowdsourcing can be a crucial part of an organization's innovation management. This study contributes to the taxonomy of crowdsourcing utilization in innovation management. The study brings out crowdsourcing types which can be*

utilized in a wide range of industry sectors. Innovation management will benefit from the use
of crowdsourcing in search, select, implement, and capture phases.

Keywords: Crowdsourcing; industrial management; innovation management;

Classification: Case study

INTRODUCTION

Organizations are developing innovation management in a wide range of industry sectors to increase their innovation capability and to get more useful products and services to their customers. Success in innovation generates profit for an organization and improves its position in the markets. Innovations create wellbeing in society in the form of new products and services. Innovative products and services establish new possibilities for organizations.

External knowledge can be a part of an organization research, development, and innovation (RDI) activities with the use of crowdsourcing. Crowdsourcing is constructed from two words: "crowd" and "sourcing". Sourcing refers to outsourcing. Customers, potential customers, employees, and other known or unknown persons are a part of the crowd. Organizations can utilize crowdsourcing in several ways; for example crowdsourcing can be utilized to evaluate an organization's new products or services.

Innovation management is the management of the innovation implementation process and it has four main phases: search, select, implement, and capture. Every phase is unique and ways of utilizing the innovation management phase's varies based on the organization and industry. Crowdsourcing types can be a part of the innovation management phases in several ways. Crowdsourcing utilization in an organization's innovation management creates value for a new product or service.

Currently crowdsourcing systems are limited to specific crowdsourcing types and these systems do not necessarily specifically support an organization's innovation activities. Results of this study can be utilized in the implementation of a new crowdsourcing information system which can be used in a part of an organization's innovation management in a wide range of industrial sectors.

LITERATURE REVIEW

This section brings out the theoretical framework of this study. Section highlights literature which is relevant for this present study. The research has two main focuses which are an innovation management and crowdsourcing.

Innovation Management

Innovations are vital in modern organizations. Innovation as a word originates from the Latin word *innovare* and it stands for making something new (Johansson and Woodilla, 2009). Innovation has several definitions based on the field of study. One thing remains the same in all the studies: it is something new or it has an element of newness. The purpose of this section is to highlight innovation definitions which are relevant this study.

Joseph Schumpeter was one of the first researchers who draw attention to innovation in his book in 1942 (Schumpeter, 2008). Schumpeter can be thought of as a godfather of innovation. Schumpeter defined innovation as a *creative destruction*. Creative destruction occurs when a new product or service enters the markets and leaves some current product or service without customers. Schumpeter highlighted that creative destruction leads to an organization's economic growth.

Modern innovation definitions are based on the innovation type which makes innovation a more complex phenomenon for research. Trott (2008) defines innovation as follows

> "Innovation is the management of all the activities involved in the process of idea generation, technology development, manufacturing and marketing of a new (or improved) product or manufacturing process or equipment".

Trott defines innovation as a management process which leads to new technology. The definition includes the development of existing products. We define innovation based on Trott's definition, but we add elements to this definition. Innovation is defined in this study as follows:

> "Innovation is the management of all the activities involved in the process of idea generation, technology, service, or process development, manufacturing and marketing of a new (or improved) product, service, manufacturing process or equipment".

The definition includes point of views for innovation types which are radial, really new, and of incremental innovation. The enhanced definition highlights service and process innovations. Thus, innovations can also be seen as social and product innovations. Types of innovations are discussed more closely in the section on typology of innovation.

An innovation can be a push or market pull innovation. In the push innovation model every innovation comes from basic sciences, proceeds to development or applied sciences and from there to manufacturing and marketing (Godin and Lane, 2013). Pull innovations come from the needs of the markets where it proceeds to development and finally to manufacturing and sales (Godin and Lane, 2013).

2.2. Typology of Innovation

Literature describes several innovation types which, for example, are technological, social, and service innovation. Innovation types are connected to an organization type. This section highlights innovation types which are relevant to this study.

An innovation is radical if a new product or service satisfies a former unsatisfied customer need for the first time (Gemünden *et al.*, 2007). A completely new market area will be developed and the organization will benefit from the radical innovation economically. Radical innovation may change customer behavior in the markets. An example of radical innovation is the mobile phone and the flat screen television.

A really new innovation is between radial and incremental innovation. A really new innovation is a moderately innovative product or service (Garcia and Calantone, 2002). A really new innovation upgrades a product or service by a great leap. Really new innovations can evolve into a new product line or create new markets with existing technology. An example of a really new innovation is the fax machine. Really new innovations are also called discontinuous innovations.

An incremental innovation presents a minor degree of departure from existing practices (Camisón-Zornoza *et al.,* 2004). It enhances the capacities already present in the organization and develops them. Improvements can be minor or major for products or services. Incremental innovation makes an existing product or service more tempting to customers. Incremental innovation is the most common innovation type.

A technological innovation is a process which generates new or improves on current technology (Nieto, 2004). Technological innovation requires research, development and learning-by-doing activities in an organization (Sagar and Zwaan, 2006). Learning can lead to better results and changes in an organization. The development of new technology can require a significant amount of resources and capital.

A service innovation is a new, better, or more effective service. Service innovations require creative activities like other innovations (Schwarz *et al.,* 2012). A service innovation can be a new or improved service concept which adds value to the customer. Service is not technological but organizations can offer services which are technology based. A service can be seen as a product of the organization.

A product innovation is a process which includes the technical design, RDI, manufacturing, management, and commercial activities involved in the marketing of a new or improved product (Alegre *et al.,* 2006). Product innovation can include technological and service solutions. Product innovation can include significant improvements in technical components or materials. The customer gains value from product innovation.

A social innovation combines several social environments which implements a new product or service (Saarnio and Hamilo, 2013). The innovation can be for example technology, product, or service. Nokia Dream Team was a social innovation. The Dream Team brought out innovations which had a wide economic effect on the Nokia Corporation. Social innovation combines two different departments or groups of professionals to develop, for example, a new product or service. Social Innovations can be created inside or outside of an organization.

Process innovations are changes in the way an organization acts (Tidd and Bessant, 2013). Process innovation generates a new or significantly improved way to produce products or services or a way to deliver them to customers. Process innovations can reduce production or delivery costs or significantly increase product or service quality.

2.3. Innovation as a Management Process

Innovation management is a process of managing innovation creation. Innovation processes vary in organizations generally but based on this research's empirical data the same main processes exist. Tidd and Bessant (2013) stress that the innovation process has four phases which are search, select, implement, and capture. Figure 1 is illustrating innovation management as a process.
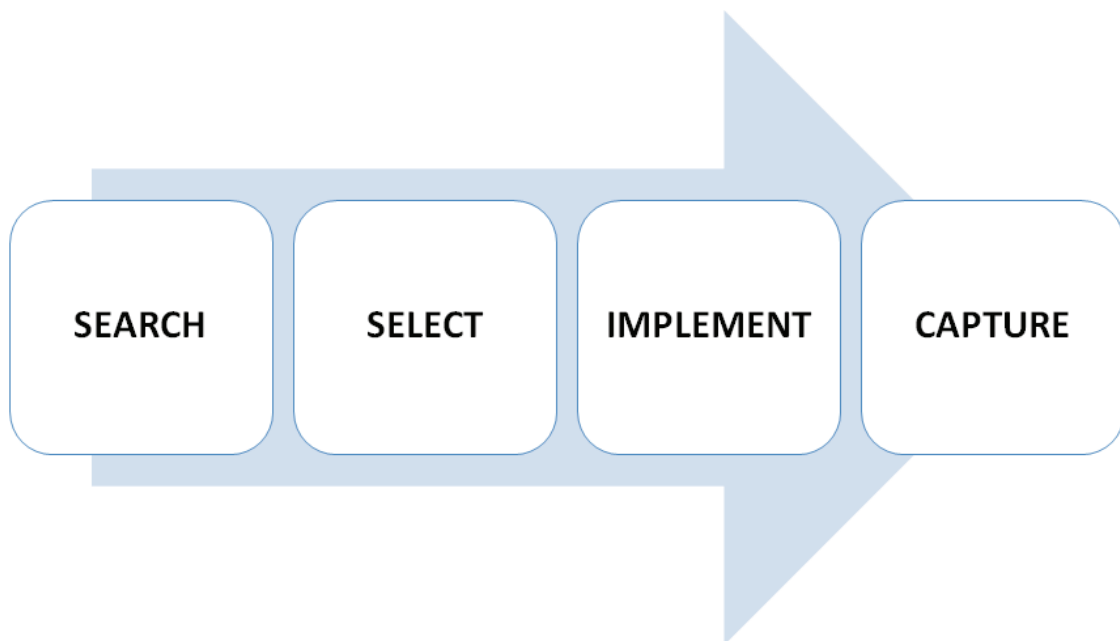
Figure 1. Innovation management four phase model (Tidd and Bessant, 2013)

Search, select, implement, and capture are the main phases. The search phase includes the scanning of an organization's internal and external environment and processing the signals which are relevant and may be developed into new products or services. The signals can be, for example, new market opportunities or ideas.

An organization makes decisions as to which signal it will response to in the select phase. This phase may include analysis of a new idea which is based on, for example, the organizations vision, strategy, or its values. The development process of an innovation can take a long time and demand the organization's resources. It is important therefore to analyze which innovation ideas will precede to the implement phase.

The implement phase carries out the new product, service, or process. The idea will be translated into innovation and launched to the organization's internal and external markets. Implementation of an innovation requires knowledge resources to develop an innovation and to execute the innovation project. The implement phase requires knowledge about internal or external markets and knowledge of the market area where the innovation will be launched.

The capture phase is the final stage of the innovation management process. Capturing value from innovation includes sustaining the innovation adoption and diffusion. Capturing is also about learning. Organizations have a possibility to learn from innovations and innovation management. This leads to the development of innovation management. All experiences in innovation management should be processed and carefully analyzed. The result of future innovative products or services is more inclusive if learning happens from former innovations and development processes.

2.4. Crowdsourcing

An organization is constantly connected to customers. At least organizations are constantly selling their products or services to customers. It is important to get the opinion of customers, potential customers, employees, and other stakeholders when implementing a new product or service. The opinion of stakeholders is important to organizations because of the better chance of making a profit when a new product or service enters the market.

Crowdsourcing is constructed from two words: "crowd" and "sourcing". Crowdsourcing is a task taking place inside or outside the normal organization setup in an undefined crowd. Crowdsourcing can be implemented, for example, between different departments, if the organization is large enough. Jeff Howe published his original crowdsourcing article in *Wired* magazine in 2006 (Howe, 2006). Howe defines crowdsourcing as follows (Howe, 2014)

> *"Crowdsourcing is the act of taking a job traditionally performed by a designated agent (usually an employee) and outsourcing it to an undefined, generally large group of people in the form of an open call."*

Crowdsourcing can be utilized in different situations and it has an effect on an organization's innovation activities when implemented as a part of innovation management. Crowdsourcing activities may include web platforms but it is not necessary.

Brabham (2008) claims that crowdsourcing is not open innovation. Open innovation can be seen as one form of product development. Open innovation is open to everyone. An example of open innovation is open source. Anyone can modify a source code and create a new product based on it. Linux is an open source product which anyone can use freely. All the parts of a product are made available to everyone in open innovation. Open innovation collects and releases RDI projects outside of an organization.

Crowdsourcing is an act taking place inside or outside of an organization and collecting the results from the crowd. An organization receives the profit and results based on crowdsourcing activities from this point of view. Projects or possible projects are not released to the outside in crowdsourcing. A common example of crowdsourcing is Wikipedia where anyone can write an article and modify existing ones. An example of crowdsourced RDI activities is InnoCentive service where the crowd is working with organizations on RDI problems.

2.5. Crowdsourcing Types

Crowdsourcing has multiple types in literature. All crowdsourcing types relevant to this study are brought out in this section. Crowdsourcing types can be overlapping. Researcher's defines crowdsourcing types in various ways based on their theories and studies.

Crowd wisdom is one of the most common forms of crowdsourcing (Sloane, 2011). An organization is using the crowd to extend its knowledge. Crowd wisdom can be utilized to extend a product's features in organization's innovation activities. This means using the crowd to construct a new idea for example. Knowledge is also dispensed within the organization in this way.

Crowd creation is the second crowd type of crowdsourcing. Customers are participating in the tasks with the actual producers; like employees (Geiger *et al.,* 2011b). The crowd can be utilized for implementing a task which benefits an organization. The problem to be solved or the task to be performed in crowd creation can have a loose definition and the task's type is generally creative (Geiger *et al.,* 2011a). There can be differences in the quality of the work which individuals create. An organization should monitor crowdsourcing activities and estimate the quality.

Microtasking enables hundreds of people to perform microwork for an organization (Franklin *et al.,* 2011). Work can be paid or unpaid. Microtasking systems, like Amazon Mechanical Turk, enable the use of the crowd in an organization's innovation activities. An organization may have its own system for microtasking. Microtasking needs verification for quality the same as other crowdsourcing implementations. Verification is typically carried out by comparing multiple responses to the same task (Gupta *et al.,* 2012).

Macrotasking is the second crowdsourcing tasking type. Macrotasking is a more extensive type of tasking and requires usually special skills and might be precisely targeted (Reid,

2013). The crowd could use a web platform for implementing a task but this is not mandatory. An organization can donate a reward to the person or persons who are implementing the task. InnoCentive is an example of a platform for this kind of activity. It is normal that the problem solver or project achiever needs to have proof of concept of the solution (Schenk and Guittard, 2010). Macrotasking can be a small part of a project, sub project, or even the entire project may be macrotasked.

Crowdvoting is utilized to organize large amounts of data. Crowdvoting can be used, for example, to judge new or old products or services (Hammon and Hippner, 2012). Crowdvoting is generally implemented through the Internet. Internet stores are commonly using crowdvoting for products and services. Customers can, for example, give stars for products or give a thump up or down opinion for an article.

Crowdevaluation is a more extensive form of crowd analytics. Crowdevaluation can be utilized, for example, as part of an organization's innovation activities for evaluating the results. Crowdevaluation may be repeatable but ranking quality should be considered (Blanco *et al.,* 2011). There can be differences between the crowd and the professionals in the quality of the evaluation.

Crowdfunding is one way to collect micro amounts of capital from the crowd (Prive, 2012). Anyone can give funding for crowdfunded project or even to a corporation. An example of a crowdfunding service is Kickstarter where anyone can finance the projects. A project called Double Fine collected 1,229,015 dollars for their PC tactical strategy game using the crowdfunding model (Kickstarter, 2014).

2.6. Crowdsourcing Utilization in Innovation Management

Tidd and Bessant (2013) allocate innovation management in four main phases which are search, select, implement, and capture. Crowdsourcing can be utilized in several ways in every phase. It should be considered which crowdsourcing task creates value for innovation. The idea behind the innovation may become exposed when crowdsourcing is utilized in innovation management. Crowdsourcing, for example, cannot necessarily be utilized in every phase in the technological innovation development process. This study is highlighting the organization's point of view in innovation management and crowdsourcing. Crowdsourcing can be utilized in organization's innovation management activities.

Crowdsourcing can be used for generating new ideas in the *search phase*. Organizations professionals can generate ideas which can be evaluated through crowdsourcing. A second way to generate a new idea and evaluate it is to use crowdsourcing and follow which ideas could have pull in the market. Product users or crowd can be utilized for generating new product or service ideas (Poetz and Schreier, 2012). Organizations are using idea management platforms which crowd can access to generate ideas about an organization's products and services. Organizations can create idea competitions where the best ideas are selected and implemented.

Dell has a service called IdeaStorm where product users can suggest product improvements or new product ideas (Dell, 2014). Public and open tools for idea generation can be used to gather information from the crowd. Examples of idea based crowdsourcing services are IdeaConnection, My Starbucks Idea, and Ideaken. Social networks can be utilized as crowdsourcing platforms to find new ideas and for forming megatrends. Social networks may be also utilized to formulate an idea.

Crowdsourcing can be used for idea or innovation evaluation in the *select phase*. There should be a rating scale indicator, prediction markets, and comparison between the rating scales when using crowdsourcing to evaluate an idea (Blohm *et al.,* 2011). Indicators tell about the quality of an idea. Crowdsourced idea evaluation aims at filtering the best ideas from the weaker ones. Nowadays, for example, idea testing can be implemented through social networks. Public crowdsourcing tools exist for the innovation management select phase. Most of the crowdsourcing types can be utilized from an organization's point of view in the *implementation phase*. Innovation implementation is commonly done with projects. An idea is turned into a project which develops an innovation or prototype of the new technology (Trott, 2008). The project can be financed with crowdfunding. Micro- or macrotasking can be used in small project tasks. Crowdvoting or evaluation can be used at the final stage of implementation to find out the usefulness of a new product or service. Which crowdsourcing forms are utilized is based on need and the type of project being carried out. Even entire projects can be crowdsourced.

Crowdsourcing can be utilized as a tool for obtaining value in the *capture phase*. An organization receives value commonly in the form of profit along with other benefits such as new knowledge. An organization can try to find new development ideas for new innovation in the capture phase. An organization can also evaluate an innovation's impact on the business environment in the capture phase. Crowd can be used for evaluating the impact of a new product or service. Crowd creation can be utilized for gathering new ideas for innovations. This way an organization may implement improvements for new products or services.

METHODOLOGY

The research is based on case studies. The case organizations have RDI activities and crowdsourcing was utilized in the organizations. Multiple persons were invited to research sessions. The amount of responders per organization was from one to nine persons. The case organizations are small, medium, and large. The responders were in: top management, line management, RDI management, project management, or were specialists.

The empirical data of this study was collected using interviews and a web survey. The study included 14 case organizations from a wide range of industry sectors. The total number of responders for the interviews and survey was 37 persons. 27 persons participated in interview sessions where they were group interviewed in their organizations. 25 of the 27 persons who

took part in the interviews also responded to the survey and two of the persons only partici-pated in the interviews. The survey had 35 responders in total. The industries involved in-cluded for example: consulting, publishing, education, networking, automation, energy, and public relations. The study includes qualitative and quantitative methods and it can be con-sidered a mixed research as both methods were utilized in data gathering and analysis.

The researcher introduced the research area to the responders. The survey had 109 questions which were qualitative and quantitative questions. The survey included questions and an-swers which are not relevant to this study. These questions and answers were excluded from this study. The terms utilized in this study were introduced to the responders. A common un-derstanding of the study was required in the case organizations before answering the web survey and taking part in the interview.

Analyzing the answers was implemented using quantitative and qualitative methods. The results were summarized and illustrated with charts and texts. The text includes an analysis of crowdsourcing utilization in the innovation management phases. The result of this study is the innovation management based crowdsourcing taxonomy.

This study can be identified as a positivistic research. The study is built on empirical data which was collected from organizations which are acting in wide range of industry sectors. The inductive reasoning method is utilized in this study. Inductive reasoning ("bottom up") is building a theory from observations (Trochim, 2006). The inductive reasoning approach is utilized for finding the patterns of crowdsourcing utilization in innovation management. The theory is constructed by applying existing crowdsourcing theories and validating them.

RESULTS OF THE STUDY

Innovation management is managing the process of innovation from the idea searching phase to the value capture phase. This research is applying Tidd's and Bessant's (2013) innovation management model which has four phases. The focus of this study was to research which crowdsourcing types are part of an organization's innovation management activities in the search, select, implement, and capture phases. The case organizations were able to find the search, select, implement, and capture phases from their innovation management processes. This leads to the conclusion that these innovation management phases are common and can be utilized in a wide range of industry sectors. On the other hand, every industry is acting in a variety of ways and because of this these processes have differences.

The first stage of innovation management is *search*. The search phase includes the scanning of an environment for getting ideas for new products and services. Utilized crowdsourcing types in this phase are crowd wisdom, crowd creation, microtasking, macrotasking, and crowdfunding. Figure 2 is illustrating crowdsourcing utilization in the innovation manage-

ment search phase in the case organizations which are taking place in wide range of industry sectors.
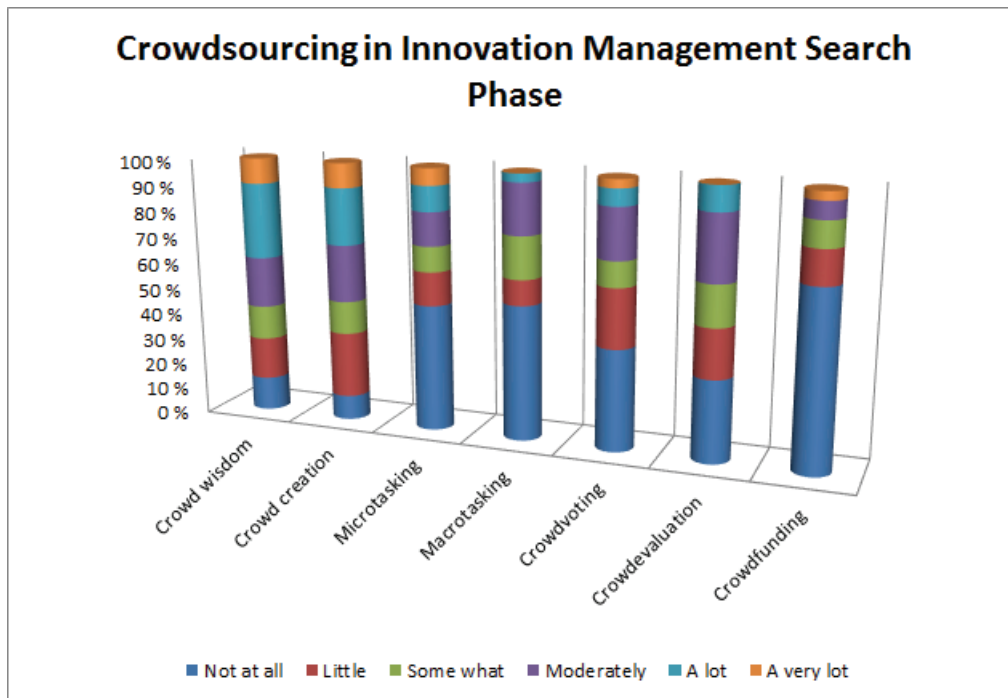
Figure 2. Crowdsourcing in innovation management search phase

Crowdfunding is one of the least utilized crowdsourcing types in the innovation management search phase. Thus, crowdfunding could be utilized for searching for innovations and finding products or services which might have pull in the markets; based on the micro amount of funding received. Crowdsourcing types which are utilizing the knowledge of the crowd are used mostly. These are crowd wisdom, crowd creation, microtasking, macrotasking, crowdvoting, and crowdevaluation. Crowdsourcing is utilized to gathering new ideas about an organization's products or services. Crowd wisdom is utilized for opening new discussions to detect which innovations could have pull on the market. This is implemented, for example, with social networks and blogs.

Knowledge based crowdsourcing types are commonly utilized for tracking ideas which could lead to innovation. Open platforms are utilized for idea generation and management. Ideas are gathered from an organization's internal and external crowd. Crowdevaluation and crowdvoting are utilized to obtain knowledge about useful products and services. This makes it easier to analyze which are the most popular products or services on the market. Crowd wisdom and creation are utilized in idea formulation. Crowd can give opinions about an idea. An organization may use this knowledge in product or service development. This could be either a small or large task or it may require special skills. On the other hand, this can be seen as a micro- or macrotask.

The next phase in innovation management is *select*. Decisions about selecting the innovation can be based on existing products or services or the organization's strategy. An organization's strategy has an impact on selecting the innovations which will be implemented. Crowdsourcing can be utilized in various ways when an organization is selecting the idea for innovation. Figure 3 is illustrating crowdsourcing types which were identified in case organizations in the innovation management select phase.
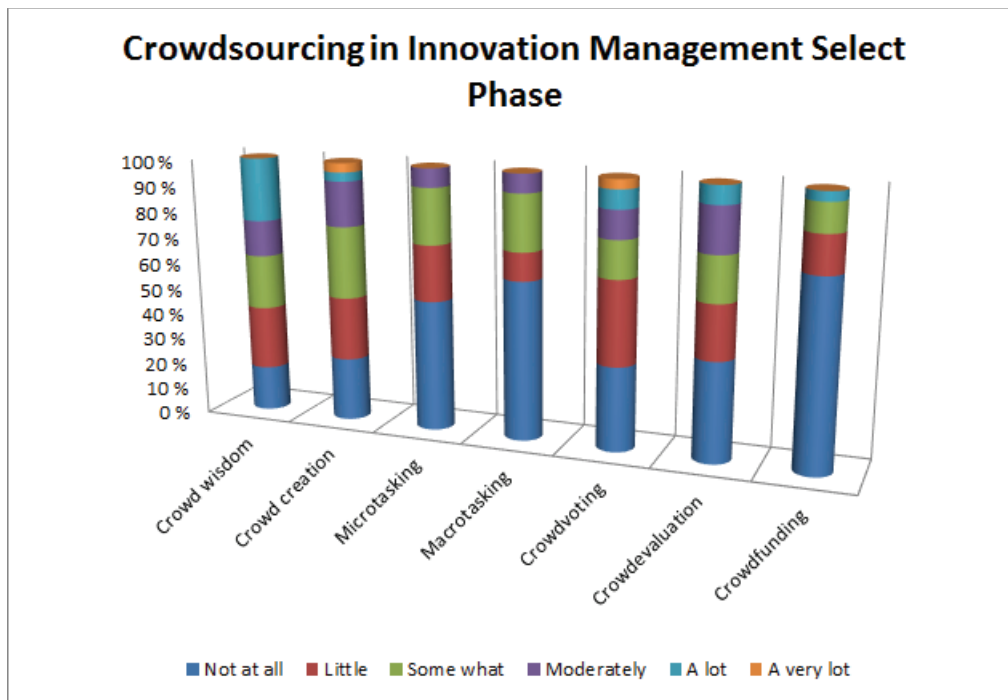
Figure 3. Crowdsourcing in innovation management select phase

Crowdfunding is one of the less utilized crowdsourcing types in the innovation management select phase. Other crowdsourcing types are utilized during this phase. Crowdsourcing is utilized for commenting on innovative ideas. Large or small crowds can give feedback about new ideas. This way an organization gets knowledge about which products or services have pull in the market. This can be crowd wisdom, crowd creation, microtasking, macrotasking, crowdvoting, or even crowdevaluation. On the other hand, it is not possible to know if a product or service has pull on the market before the new product or service is launched. Thus, this only gives the prediction; does the new product or service have customers at all. Crowdvoting is utilized for voting for the best solutions from several possibilities. This separates the good ideas from the bad ones.

Crowdsourcing is utilized in the testing of new products or services. A product's or a service's upcoming customers are involved in the development process at an early stage so as to make the correct decisions about the product or service's development. An organization's internal crowd wisdom and crowd creation are utilized in team discussions and process evaluations. Social media is utilized to obtain the knowledge from an external crowd when select-

ing the idea. Social media tools like Facebook, Twitter, LinkedIn, and GooglePlus are utilized in this phase. External crowdsourcing platforms like InnoCentive and Amazon Mechanical Turk were not utilized in case organizations. Organizations have their own crowdsourcing platforms which were widely utilized in the case organizations activities. Final selection decisions are made by management, employees, financiers, and owners but the crowd can support these decisions.

The next phase in innovation management is *implement*. This phase includes the development of new products or services. Development of a product or service is implemented commonly using projects. Organizations are utilizing crowd creation for planning in part the new product or service. Organization's internal crowd creation was utilized in project planning to generate a more realistic project plan. Figure 4 is illustrating crowdsourcing usage in the innovation management implement phase.
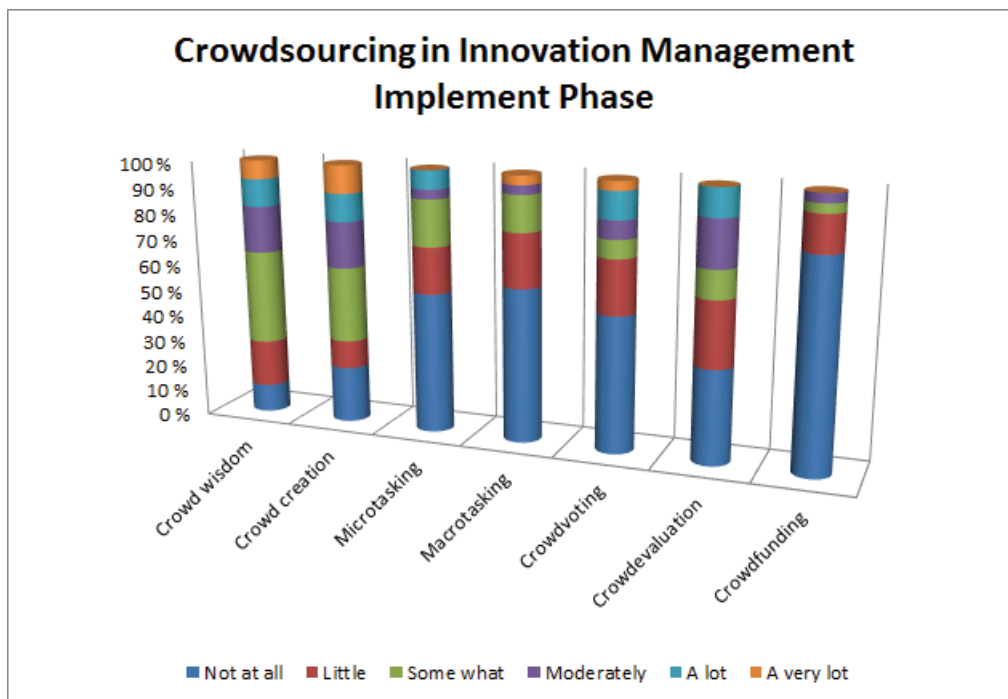
Figure 4. Crowdsourcing in innovation management implement phase

Knowledge based crowdsourcing types are the most utilized crowdsourcing types in innovation management implement phase. Crowdfunding is again the less utilized crowdsourcing type. Other crowdsourcing types can be utilized during the innovation management implement phase. Social networks are commonly utilized in organization's crowdsourcing activities. Organizations have development groups in social networks which are seen to be useful during the innovation implement process.

Crowdsourcing activities can be either internal or external during this phase. Recruitment to product testing is implemented using crowdsourcing. However, an organization is selecting the persons who are participating in the product or service testing. Crowdvoting and evaluation are common crowdsourcing types for judging a new product or service in the innovation management implement phase. This can be seen as crowd wisdom, crowd creation, microtasking, or macrotasking depending upon the scope of the activity.

Product or service testers can give grades to indicate the best product or service. This can be seen as crowdvoting or evaluation based on the scope of analyzes which the crowd implements. A product or service is improved through crowdsourcing. The case organizations have tools for this process. The crowd will crucially affect the development process. Some organizations have carried out beta testing using crowd wisdom and crowd creation. This is common in industries where IT is strongly involved. A public link is sent to social networks where testing can be done by a limited amount of users and feedback given about the new product or service. Organizations can be in touch with client's customers during this phase using crowdsourcing. This makes a new product or service more tempting for customers because the development process is affected by the upcoming customer. This could lead to better products or services which may have more pull on the market.

The last stage of innovation management is *capture*. An organization is capturing value from the innovation in this phase. The value can be for example: financial reward, an effect on the business environment, a social effect, or ideas for new innovations. Crowdsourcing is utilized during the innovation management capture phase. Figure 4 is illustrating crowdsourcing utilization in the innovation management capture phase.
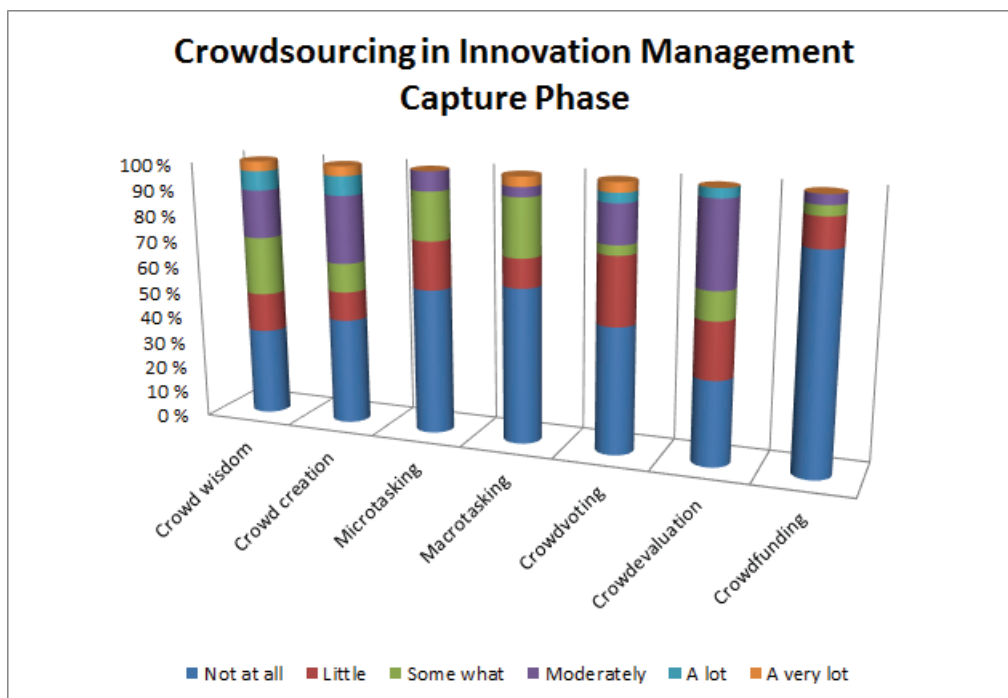
Figure 5. Crowdsourcing in the innovation management capture phase

Crowdfunding is less utilized in the innovation management capture phase. Organizations are using crowdsourcing to evaluate innovation implementation. This can be seen as crowdvoting or evaluation. Crowdsourcing is utilized mainly for knowledge creation using crowd wisdom or crowd creation. Knowledge is created through a network of actors from the different sectors of industry. The results are analyzed using crowdsourcing. Knowledge of the corporate actors is used in the form of crowd wisdom in this situation.

New ideas which may lead to innovation are gathered from the crowd during this phase with crowdsourcing. Feedback from the crowd can lead to new business solutions and innovation can be applied to other business environments as well. This leads an organization to new markets and creates opportunities. Organizations are collecting new feature ideas for their products or services during the capture phase. Innovations change organizations reputation in a positive way. Crowdsourcing can be utilized for managing a companies' reputation.

Crowdsourcing is utilized for innovation management process evaluation. Crowdsourcing is used for marketing purposes and for the company to get feedback on a new product or service. The crowd is acting as marketers in this case. The innovation management capture phase is the last stage of innovation management. However, this leads to new innovations and development activities. This creates a loop for innovation management.

CONCLUSIONS

This research was focusing on how crowdsourcing is utilized in organizations' innovation management within a wide range of industry sectors. The study was applying the four phase innovation management model. Crowdsourcing is utilized in the case organizations in innovation management. Utilized crowdsourcing types are common and can be used in a wide range of industry sectors. Crowdsourcing utilization accelerates an organization's production of innovations.

Crowdsourcing increases innovation capability and the possibility to create innovations with more market pull. Crowdsourcing brings customers, possible customers, and other known or unknown persons more closely and intensively to an organization's innovation activities. On the other hand, crowdsourcing includes risks which organizations should consider before implementing crowdsourcing activities. Risks associated with crowdsourcing needs more research.

Crowdsourcing was seen as vital in the case organizations. More and more external and internal knowledge is needed in an organization's innovation management when the nature of that organization's business area is to be creative. However every innovative idea cannot be implemented in an organization. An organization always needs to consider resources and internal knowledge before innovation implementation. On the other hand, in some case or-

ganizations crowdsourcing was not the standard way to act. However, in some case organizations crowdsourcing was a part of the organization's culture and it cannot be separated from innovation activities.

Crowdfunding was the least utilized crowdsourcing type in all case organizations. More research is needed about crowdfunding into why it is used less during the innovation management process. Crowdfunding makes it possible for anyone to be involved in the funding and development of a new product or service. Crowdfunding may work also as a channel for marketing upcoming products or services. Crowdfunding creates hype around new products or services which makes it easier to market them. Innovations are generally developed with projects. Crowdsourcing can be utilized during the project lifecycle. More research is needed into crowdsourcing types used in the project lifecycle.

Crowdsourcing was utilized in the case organization's innovation management but not as widely as it could be used. On the other hand, crowdsourcing is a new way to act for many organizations and it needs development so that it could be utilized more closely in innovation activities. Organizations can use internal and external crowd in innovation activities in many ways. However, it should be considered carefully which types and phases in the innovation management process that could utilize crowdsourcing and create value for new products and services.

REFERENCES

1. Alegre, J., Lapiedra, R., and Chiva, R. (2006), A measurement scale for product innovation performance. *European Journal of Innovation Management*, Vol. 9 No. 4, pp. 333-346

2. Blanco, R., Halpin, H., Herzig, D. M., Mika, P., Pound, J., and Thompson, H. S. (2011), Repeatable and Reliable Search System Evaluation using Crowdsourcing. *SIGIR '11 Proceedings of the 34th international ACM SIGIR conference on Research and development in Information Retrieval*, pp. 923-932

3. Blohm, I., Riedl, C., Leimeister, J. M., and Krcmar, H. (2011), Idea Evaluation Mechanisms for Collective Intelligence in Open Innovation Communities: Do Traders Outperform Rates? *Thirty Second International Conference on Information Systems*, pp. 1-24

4. Brabham, D. C. (2008), Crowdsourcing as a Model for Problem Solving: An Introduction and Cases. *The International Journal of Research into New Media Technologies*, pp. 75-90.

5. Camisón-Zornoza, C., Lapiedra-Alcamí, R., Segarra-Ciprés, M., and Boronat-Navarro, M. (2004), A Meta-analysis of Innovation and Organizational Size. *Organization Studies*, Vol. 25 No. 3, pp. 331-361

6. Dell (2014), "Idea Storm", available at http://www.ideastorm.com (accessed 12th of April 2014)

7. Franklin, M. J., Kossmann, D., Kraska, T., Ramesh, T., and Xin, R. (2011), CrowdDB: Answering Queries with Crowdsourcing. *SIGMOD '11 Proceedings of the 2011 ACM SIGMOD International Conference on Management of data*, pp. 61-72

8. Garcia, R., and Calantone, R. (2002), A critical look at technological innovation typology and innovativeness terminology: a literature review. *The Journal of Product Innovation Management*, Vol. 9, pp. 110-132

9. Geiger, D., Rosemann, M., and Fielt, E. (2011a), Crowdsourcing Information Systems - A Systems Theory Perspective. *22nd Australasian Conference on Information Systems*, pp. 1-11

10. Geiger, D., Seedorf, S., Schulze, T., Nickerson, R., and Schader, M. (2011b), Managing the Crowd: Towards a Taxonomy of Crowdsourcing Processes. *Proceedings of the Seventeenth Americas Conference on Information Systems, Detroit, Michigan August 4th-7th 2011*

11. Gemünden, H. G., Salomo, S., and Hölzle, K. (2007), Role Models for Radical Innovations in Times of Open Innovation. *Creativity and Innovation Management*, Vol. 16 No. 4, pp. 408-421

12. Godin, B., and Lane, J. P. (2013), Pushes and Pulls: Hi(S)tory of the Demand Pull Model of Innovation. *Science, Technology, & Human Values*, Vol. 38 No. 5, pp. 1-34

13. Gupta, A., Thies, W., Cuttrell, E., and Balakrishnan, R. (2012), mClerk: Enabling Mobile Crowdsourcing in Developing Regions. *CHI '12 Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pp. 1843-7852

14. Hammon, L., and Hippner, H. (2012), Crowdsourcing. *Business & Information Systems Engineering*, No. 3, pp. 163-166

15. Howe, J. (2006), "The Rise of Crowdsourcing - Wired 14.06", available at http://www.wired.com/wired/archive/14.06/crowds_pr.html (accessed 12th of April 2014)

16. Howe, J. (2014), "Crowdsourcing: A definition", available at http://www.crowdsourcing.com/ (accessed 12th of April 2014

17. Johansson, U., and Woodilla, J. (2009), Towards an Epistemological Merger of Design Thinking, Strategy and Innovation. *8th European Academy of Design Conference*, pp. 1-5

18. Kickstarter (2014), "Double Fine's MASSIVE CHALICE", available at http://www.kickstarter.com/projects/doublefine/double-fines-massive-chalice (accessed 12th of April 2014)

19. Nieto, M. (2004), Basic propositions for the study of the technological innovation process in the firm. *European Journal of Innovation Management*, Vol. 7 No. 4, pp. 314-324

20. Poetz, M. K., and Schreier, M. (2012), The Value of Crowdsourcing: Can Users Really Compete with Professionals in Generating New Product Ideas? *Journal of Product Innovation management*, Vol. 29 No. 2, pp. 245-256

21. Prive, T. (2012), "What Is Crowdfunding And How Does It Benefit The Economy – Forbes", available at http://www.forbes.com/sites/tanyaprive/2012/11/27/what-is-crowdfunding-and-how-does-it-benefit-the-economy (accessed 12th of April 2014)

22. Reid, E. F. (2013), Crowdsourcing and Gamification Techniques in Inspire (AQAP Online Magazine). *IEEE Intelligence and Security Informatics (ISI) 2013*, pp. 215-220

23. Saarnio, J., and Hamilo, M. (2013), *Innovaation alkulähteillä (In Sources of Innovation)*. Tammerprint Oy, Tampere. ISBN 978-952-238-105-7

24. Sagar, A. D., and Van der Zwaan, B. (2006), Technological innovation in the energy sector: R&D, deployment, and learning-by-doing. *Energy Policy*, Vol. 34, pp. 2601-2608

25. Schenk, E., and Guittard, C. (2011), Towards a Characterization of Crowdsourcing Practices. *Journal of Innovation Economics*, Vol. 2011/1, pp. 93-107

26. Schumpeter, J. (2008), *Capitalism, Socialism and Democracy*. Harper Perennial Modern Thought, New York. ISBN 987-0-06-156161-0

27. Schwarz, S., Durst, C., and Bodendorf, F. (2012), A Conceptual Framework of Service Innovation and Its Implications for Future Research. *2012 Service Research and Innovation Institute Global Conference*, pp. 172-182

28. Sloane, P. (2011), *A Guide to Open Innovation and Crowdsourcing: Advice from Leading Experts*. Kogan Page Limited, London. ISBN 978-0-7494-6314-4

29. Tidd, J., and Bessant, J. (2013), *Managing Innovation: Integrating technological, market and organizational change (5th edition)*. John Wiley & Sons Ltd., United Kingdom. ISBN 978-1-118-71694-6

30. Trochim, W.M. (2006), "Research Methods Knowledge Base (2nd Edition)", available at http://www.socialresearchmethods.net/kb/ (accessed 12th of April 2014)

31. Trott, P. (2008), *Innovation Management and New Product Development (4th edition)*. Pearson Education Limited, England. ISBN 978-0-273-71315-9

POLICY INNOVATION FOR INTERNET FUTURE AND NEW TECNOLOGIES
(E-DEMOCRACY, RIGHT TO BE FORGOTTEN AND ELECTRONIC SOCIAL-CONTROL)

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ABSTRACT

The Internet is the main tool for communication and it is at the same time the most important and the most simple tool for social control. The web is certainly a virtual public space based on intentions and democratic principles of access and participation but it is not specifically a democratic environment in all effects. It represent a social window where everyone plays a specific role by national institutions, individual movements of thought and protest. The aim of this paper is to envisage effects of electronic society in private life, social virtual control and changes for citizens in social approach and public life. The Internet allows speed and easy way of contact but also simplicity and accuracy of expression in ideas control, a simple and non-expensive way to trace outbreaks of dissent and shield any criticalities from the first events. These technological developments are creating new categories of primary rights classified as online human rights, the right to be forgotten an evolution of the old right to be alone which is not the right to be leaved alone as web-citizen as it is in the social electronic sphere. The social-networking is not just simply sharing, it's a new philosophy of public life, a social platform of intense human interaction, a controlled accreditation scheme, a non-private sharing space, a system of immediate publication of ideas rightly or wrongly, to the detriment of human rights and confidentiality of communications. This new digital State full of contradictions is always under control of policy-makers and Government despotic regimes that works aggressively on this field while the population are directed towards the globalized world with the disappearance of nationalities and their banners in direction of electronic a common digital State accreditation. The role of future policies on the web cannot be limited solely to the production of laws without taking into account social realities and government capacity in prediction of human behaviour and progressive transformation.

Key words: Social online rules-Social Control, online accreditation, Utopianism

INTRODUCTION AND CONTENT

In the age of personal participatory media. Internet generates a new feeling of public belonging that comes from technological knowledge and not from nationality. A recognition and mutual accreditation that cross national boundaries and doesn't need more symbols such as the flag or national music, a form of atypical membership contextualized in a citizenship in

virtual reality. The virtual environment open to cooperative natural spirit and artificial collaboration through manifestations of mutual solidarity and common interests expressed through self complaint desires.

Virtual world evolves in social powerful platforms of human interaction characterized by massive and intensive participation giving rise to the birth of complex social relationship and the formation of virtual communities[1] .Human electronic nature is an agglomerate based on common electronic language and the anonymity of the web. The network determines a new online public life where people are citizens of the Technological State where Government and norms are intangible assets lack of consistency. The social-network system is characterized by aggregation and simplicity of expressed relationships through sharing, a condition that multiply this effect by exporting personal data and importing uncertainties and personal difficulties in social approach that reveal themselves in social life where human relations and human rights do not evolve at technology step. Social-networking is a new policy presence in the world, a new instrument but in particular a new part of public society based on intercultural citizens who do not feel citizenship and national identity but it considers to be part of the social electronic society that dematerializes relations and virtues of the material world. An escape from reality into infinite spaces of supposed legality. On The web every citizen exercises a renunciation of personal sovereignty, a renunciation of personal data process and the managements of its powers to private entities not necessarily able to protect them as personal property but well aware of the commercial value of this abdication and the use of stolen data without awareness of users. The political and social system built over the centuries, flexible to small and modest gradual changes collapsed with the evolution of technology failing in its remotest certainties. The analogical world has lost its certainties and concreteness to the digital world which has reduced the time and ways of knowledge providing information but not the accuracy and safety.

THE NEW SOCIAL-DIGITALAGREEMENT AND LIQUID SOCIETY

The new social inclusion generated by technology does not take account of the old agreement Citizen- State, but it start from the new agreement User- Private Company. Technology companies will override the State in the provision of services, with an occult or actual payment, replacing the State not more able in what it can no longer provide, access and network connections. The original Pact between State and individual broke as Touraine. The original transfer of the rights of autonomy and freedom in favour of the State whose dual contract was generated by new certainties and rights guaranteed by the State has no raison d'etre. The new relationship between the individual and society and its institutions does not provide anachronisms, but analysis of new requirements and updating of rules and roles. The State remains the control function, without power control function is delegated to the private companies. This happens in democratic States as an effect of companies State agreement, in despotic States such functions are carried out by individuals, but always under the direct

control of the State. The new Liquid society theorized by Baumann bases its existence and its evolution on the immateriality of everyday life, on the inconsistency of the new social relations and social values shift increasingly away from democratic content, institutional, Government, personal, professional and family that had characterized for centuries the determination and evolution. The network, in its procedures and use, enhances the individual at the expense of the public social life, putting in crisis universally values recognized for centuries.

The new social relations and social relationships mediated by the web call for plurality and multiplicity without consistency, a multitude (similar to those of Spinoza) that in the context of classification and protection of the rights arising from it, is unable to enforce minimum coding rules, affirmation and respect. The right of the net, and all the new rights on the web are certain rights but they are not officially recognized. They need to be processed and encoded by generating new safeguards. It is logical to ask whether all rights on the net are fundamental rights and which of them are classified as human rights; these questions still not have answers at the moment but generate questionable continuous violations and individual freedoms upon which the doctrine and jurisprudence are truing to have a primitive approach and official position based on deregulation, the analogy and common sense, in the absence of a formal regulation, an unwritten code that of its own essence in single education degree. The absence of rules raises the absence of democracy and of basic principles. The analogical society rules arose after centuries of struggles and wars for the assertion of rights and values. The rules of the web are the vulgarization of a private technology born in one State and offered to the international community for public use, without maturation of values, without ideological contrasts, without fighting but with principles established by third parties and observed by all. Liquid society is accommodating, passively accepts everything without rebel, at least until the early privacy violations.

FROM DIGITAL DIVIDE TO E-DEMOCRACY AND CONTROL
Facing that from the first general problem of digital- divide, new social problem inside the same country or the same region of the world is a matter of necessity rather than opportunity but also of humanitarian conditions to guarantee to every social context. It's impossible not to consider that e-democracy is only a part of the most important problem of democracy in certain geographic areas but, as it's known, not all the population of the world has free access to internet services and information and it could be a consequence of money, or the result of a politic choice based on the control of independence and information in countries against democratic principles or with a vision of them totally used regime needs, without admitting interference from the International Community always attentive to the free movement of ideas considering the web as a tool of travel and disclosure. So the meaning of the words "free access" is wide, too ample to close it in a few words .It concern access to internet, services without money and copyright, and complete access to web information not under control. At the same time Information Technology means access to thought and modernity, to the right in general and rights in particular, to minimum levels of socialization unshielded

from totalitarian controls and not directed to unintended preferences and requests. Unique way to take notice and awareness of access era theorized by Rifkin. The discussion is huge and it involve human rights and social programs and it will probably absorb the work of all the world institutions . It probably takes a new Breton Woods in the field of Democracy, Privacy and Information technology. The main requirement for users is a safe and conscious use of the web to take advantage from all the capabilities and possibilities turning into real wealth, generated by the web and its characteristics. Internet free use, intended without any form of control and risks for people in general and children in particular, is the main step for healthy development of technology as a tool at the disposal of the man, citizen, users which the State guarantees services, access and freedom of movement on the net. Internet must be an open-source technology to find information, a service offered from the society without booking or service rights so that what is present in the network can be developed freely and create new forms of technology available, a direct emanation of thought and of the free movement of ideas that an open source system would strengthen freeing the shackles from market constraints mean, dumbing down the technology and making it open to all and not a privileged club making it real social capital available. The web from the one hand, in his economical prospect, is an un-material market and the best way to develop commerce easier. It appears to be essential for company's survival and growth. Developing e-commerce is possible to reach people on the other side of the world and reach new countries and markets improving capabilities and the time to market. The security of e-commerce system, which ensures authorized and correct transaction processing possibly without risks and threats, is one of the most critical issues in implementing the system. In this system a special position is occupied by new forms of communication known as social-network offering multiple possibilities and use and universally used by all generations regardless of whether security and exhaustive international legislation. The web and its forms of participation such as social network and ecommerce are forms of voluntary participation, which generate commercial data collection for marketing and security data for control, exercised by private companies often at the request of countries to generate the control

NEW PARTICIPATION AND POLICY
What is at stake is the participation, the presence, being part of a system in which everything is part of all and the worst thing that can happen to a person is to be considered out from this system of participation, with unspeakable implications in various fields of the society. Modern society pushes for participation and inclusion at any price and by any form. The citizen becomes a marketable commodity and is happy about this new status generated by free NET services, the high price to be paid is to be treated as a saleable commodity, and expendable. The User has his own outsourced private life by letting it managed to third parties. New business strategies are focused on the involuntary participation of subjects members of the Social network by exposing them to the attention of marketing which colonizes them with unsolicited bulking email and advertising. The sharing on-line activity has a very high price to pay, in terms of loosing personal part of life shared with an interested system of storage and marketing, policy and control. Participation means to be on sale as

their own market benchmarks where interests and personal experience become marketable or unconsciously on sale. In this un-friendly and un safe place of recording personal like and dislike, tastes, interests, opinion , religions and politically matters everything is on a window-glass in the main street of the world on disposal of marketing and policy researchers who want to find points and people to consider, to follow, to consider and to spy. A participatory platform with a friendly system of sharing based on mutual recognition and accreditation. A structured environment, a sort of natural reserve of potential customers, followers or dangerous political opponents to be checked assiduously whose tastes are well expressed, spontaneously and particularly by moving into a form of political or commercial outing. Is technology, at the end, considerable as an help from this point of you? Is it a mass construction weapon ?As it was defined by an international review some years ago. It's amazing the world failing to develop democratic principles in the real world and start investing time and money in cyberspace, as if freedom and human rights must necessarily pass from the network in order to make landfall in the real world. The international freedom agenda is full of technological concepts and brands as Facebook, Twitter and Google but pour of serious intentions against control and violation of rights. the enthusiastic belief in the liberating power of technology accompanied by the urge to enlist international majors in the global fight for freedom is always on policymakers agenda in every in every political campaign and in any political program that can generate the illusion of awareness of problems and technological capability to solve them. The international concern that the internet favors the oppressed rather than oppressors is a misunderstanding, an effect of no reflection on systems, politics and results a way for seeing in another direction(this idea is called cyber-utopianism). Technology is rapidly in advance without rules and without control taken by time and by the right. Generous donation from west countries generate the opposite result between intention. The fervent conviction that giving enough money, gadgets, connectivity and foreign funding dictatorship can be removed and doomed it's an illusion and an effect or Google doctrine. Each revolution is similar but not identical to the other; Iran revolution on 2009 is similar to Warsaw, Prague, Leipzig revolution in the fall of 2198, political differences of crowds and the similar enormous belief in the power of technology (Tv, Radio free Europe, Voice of America in the past, Facebook, Google, Twitter, Blogs, email mobile technology today). A full analysis of all forms of repression and on-line control (Evgeny Morozov 2011) in which is argued authoritarian regimes have frustrated the intentions of techno-utopians. The analysis of the scholar admits also the virtues of network but with the express invitation to consider case-by-case basis the impact of the international policy network without necessarily dwelling on the positive effects but by analyzing the phenomenon with critical spirit). In Iran, the potential of the web, blogs, chat rooms and social networks are exploited by Government control and censorship, until trigger locking mechanisms of online communication (lately in February 2012 for four days to mark the anniversary of the Islamic revolution on February 11.

The contents of the web are often referred to, in this country, as immoral. The Government has repeatedly announced the opening soon of an Iranian national Internet, pure and respectful of the principles and endorsed by Government policy.

A strong reflection to do is why in equality of conditions, with the best technologies available, the results of several revolutions over times are different, what is the mistake, what are the conditions, which tool has failed considering

premises, What happened to the support of technology, the security of being able to use it without fear, where is the instrument able to spread democracy? These questions are accompanied by pain, did not answer some, but doubt that the instrument is not so effective for the purpose is certainly. The technological answer of despotic governments don't was swift and technology, weapon of attack turned out to be the best defensive tool, a valuable ally of dictatorial governments.[2] For regime authorities contact between western governments and the help of international technology firms are dangerous and create a climate of suspicion create a climate of suspicion on communications and collaborations that are considered to cause the collapse of the regimes or pitfalls to despotic governments who feel bypassed by direct contact with its citizens and the pockets of internal dispute that works for regime change. Regime political organization works for internal technological control supervising blog, email, chat and various form of contacts, Cyber-team are setting-up with function of special control with the aim of controlling communications, spread news, complacent information and event, often contrary, to direct internal ideology and extinguish hotbeds of dispute, the protesters are achieved and arrested for activities against the regimes. Technology, through such systems, becomes at disposal of despotic governments and service against the people and fundamental freedoms. Modern dictators have their own profile on the web, they answer automatic responding systems to citizen questions, they are able producers of information capable in finding threats and using technology for helping the survival of their oppressive policies. A lot of site pro-government are setting-up with video of the population with the crowd acclaiming the Government and policy in act. On the web is, obviously, difficult to find evidence and Governments undemocratic have learned how to use propaganda and tolls to manipulate information, conversations and technological evidence against someone in the direction of misrepresentation of reality. Often, the dirty work of monitoring communications on blogs and in chat is referred to by flourishing software company whose products are soldiers and secret agents perfectly able to steal ideas, to tackle them and deliver them to their employers(Government customers) ready to crackdown and to stop outbreaks in the bud without ache public opinion can intervene. Global companies are not happy in this role of censorship and it cost them a lot in terms of ambition and good name and seek to reconcile the budgetary needs and conscience running the risk of losing domestic customers in favor of public. Censorship is done by technology intermediaries(blogs, social-network) rather than governments or for governmental delegation, the way to defend e-

democracy and free circulation of ideas is founding and defending free communication and free technologies. The net access is a great tool in the hands of despotic governments to exercise control and to drug people with content specifically identified (not just propaganda but also gambling, pornography, filmography conditioning) can distract users from creating major problems posting and apathy toward Government policies, technological and sophisticated opium well-organized who drugged people creating distraction from the main issue and habit-forming. Human rights are a long way from the real protection from unscrupulous company business. Direct or indirect participation of government delegates into blogs and social network, as it happen, to control and to convert people to government policies is an actual risk and a normal practice for regimes. The new frontier is the decentralization of such activities given in outsourcing to private companies connived despotic governments for reasons of profit and praised by their Governments for the prosperity and their invoiced. A tool not just to protect and above all ever worthy of the Nobel peace prize that a lot of people and magazine want to assign to the web. The ability to upload content freely without costs does not, in itself, guarantee transparency and honest information being manipulated and distributable online easily through a sophisticated system of control that removes the primary internet feature of effective democratic tool, while recognizing the enormous potential. Western Government can't solve censorship problems by producing new tools, They need to talk, open publicly debate and discussion and legislate against each of those numerous companies that help despotic governments in controlling, without helping them economically using funds, and without maximize its expression as quality and production models which in reality are often at the service of Governments illegal and against human rights and their need to strengthen their ideological supremacy. In brief, aid to oppressed people also pass by international policies, developed with attention to technological references without participating, even passively, to regimes tactics, often good customers of the youth companies and software-and digitize oriented whose profit is independent from consciousness. Western policies are officially unable in helping people in social affairs and are not able in resolving problems themselves have helped to create. International policies driven by global institutions should strive for liberalization of freedom in communications and blogs creating standards facilitating the exchange of ideas and information by creating mechanisms for punishment and sanction for countries that do not adhere to the treaties and rules, creating a code of ethics for companies whose violation can affect access to markets.

CONCLUSION

In the light of the foregoing, the institutions cannot dismiss the problem of network management and its instruments, delegating to individual national Governments web policies. Although not all of the world's population is connected, the part of it that uses the web deserves respect and regulation through a strict international regulations that lay at the heart the citizen-user-consumer free to show their ideology and their own religion. The hope is to convince politicians of the importance of changing educational systems for the web

respecting privacy involving in new policy of control and security. Internet will be our future and in this future we want to be safe in the un-material world and so it's necessary to act policy to reduce every kind of digital divide in the world, in every field. An international policy of information of web risks is necessary crossing all the international borders, starting from new teaching. The analogical world, and now the digital one, need coordination and rules of control not for direct private interests but for public necessity. An international electronic law coordinate for the harmonious development of the web, a system of rules accepted and adopted by all the digital world, the possibility of free access and adoption without costs, the adoption of rules of protection of human rights and primary standards from worldwide analogical and digital, including through the exchange of best practice, exporting democracy and e-democracy not through money and funds but with targeted education policies, and literacy compared, are the only useful forms to use the money allocated and often squandered without any utility. These simple rules, if adopted, can give us the answers that we look at our future and that of the web. The belief that democracy, even online, is not exportable as a common product, but must be taught through knowledge is a constant that from the analogical world moves to digital one without suffering alterations, finding new life and new expressions in technology. We cannot stop technology because we cannot stop the time and we want in our future more safety than our present. The technology cannot be stopped as is not possible to stop progress, and to be considered useful and indispensable it must be part of the process of transferring knowledge gained from previous generations with the constant strengthening of rights and achievements in every field. World scandals happened about data management and privacy of global summits have changed the world's primary needs. From several parts referring to multiple Internet understood as the existence of more Internet one for each State. This process, if true, will cause the end of sharing, the rise of digital borders and the growth of business intelligence control and reciprocal control between States without authorization and the rise of online intelligence, already existing but amplified. The network of the future could be made by non-shareable closed territories and separated from endings and different languages, Internet in Chinese, Cyrillic or Arabic language is not accessible to all the world for a problem of language,, like the current network under the US Government is now accessible to everyone in terms of access without control and without permission. The network moves away from its primary digital idea of participation we are going to the fragmenting into multiple digital society. Future policies will start in any case from this point and digital rules will be probably single for each State with the end of social participation and sharing.

BIBLIOGRAPHY

1. BAUMANN Z (2002) *Modernità Liquida*, Laterza, Roma
2. BORGES J.L.(1998), Funes his memory, Collected Fictions,Viking, .
3. CATE F., (1997)Privacy in the information age.
4. LESSIG L.,(1998) Code and other Laws of Cyberspace.
5. MAFFE' C.A.,(2007) Shared Identity: social networks and companies,

6. MEREDITH P.,(2006) Facebook and the Politic of Privacy,Mother Jones,Sept.14

7. MOROZOV E., (2011)The Net Delution: The Dark Side of Internet Freedom.

8. MOROZOV E. *(2011)* L'Ingenuità della Rete,Codice Edizioni,Torino

9. NISSEMBAUM H.(1998), Protecting Privacy in an Information Age: The problem of Privacy in Public – Law and Philosophy,.

10. PALFREY J., GASSER U., Born Digital: understanding the first generation of Digital Natives.

11. RAZZANTE R. (2014) Manuale di diritto dell'Informazione e della comunicazione, Cedam

12. RULE J.,(1974) Private Lives and Public Surveillance: Social Control in the Computer Age- Schocken books.

13. ROSEN J.,(2004) The Naked Crowd: Reclaiming Security and Freedom in an Anxious Age- Random House.

14. SHIH C.,(2011) The Facebook Era: Tapping on-line Social Networks to Market, Sell and Innovate.

15. SOLOVE D.J. (2007)The future of Reputation, Yale University Press.

16. TOURAINE A. (2008) *La fin des societès. Le Couleur des idèes*, SEUIL

17. VAIDHYANATHAN S.,(2012) The Googlization of Everything.

18. WEBER S.,(2004) The Success of Open Source, Harvard University Press, Cambridge.

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INVESTIGATE THE FACTORS AFFECTING THE AVAILABILITY OF MOBILE PAYMENT - A CASE OF EASY CARD

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ABSTRACT

Purpose: Mobile payment is a major concern in the electronic commerce field. The mobile payment systems develop rapidly. In Asian countries, the most successful mobile payments model is Japan's Suica card. In Taiwan, Taipei Easy Card Corporation publish the Easy Card. This card is not only used in public transport vehicles but also can be used in convenience store and even rent a bicycle. In 2012, Easy Card had been issued more than thirty-five million in Taiwan. The daily transaction of Easy Card reaches 4.71 million times. That purpose of this study tried to discovery what are the factors that impact user to use the Easy Card, and then provide the suggestion to improve Easy Card system. In this study, the technology acceptance model (TAM) of perceived usefulness and perceived ease of use are as the factors. Besides, the security will become another factor because the issue is the one that users may worry about the leakage of information. Finally, the factor of service quality will also be considered. The questionnaire will be designed based on the perceived usefulness, perceived ease of use, security and service quality that will affect user's attitudes and intentions.*

Methodology/research: We use the Internet to issue questionnaires. The scales used in this study consisted of 28 items. The questionnaires indicated their agreement with a set of statements using a 5-point Likert-type scale. SPSS18 is applied to do the Reliability Analysis. The results of*

perceived usefulness, perceived ease of use, and service quality are greater than 0.7. Only security`s reliability is 0.5.

Finding: *In Easy Card case, perceived usefulness, perceived ease of use, and service quality impact the user`s attitude. Then, we will adjust the factor of security and add the factor of time. Thereafter, we will issue the questionnaires on Internet and in person of total 200 then analyze by structural equation model.*

Key word: Mobile payment; Theory of Planned Behavior (TPB); Technology Acceptance Model (TAM); Easy card

EVOLUTION AND CHANGE DYNAMICS IN BUSINESS ECOSYSTEMS: RESEARCH FRAME FOR SPATIAL CONTEXT

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Purpose: *Competition in different industries is moving from individual companies towards business ecosystems, where companies must proactively develop mutually beneficial relationships with various organizations. The purpose of this paper is to study the phenomenon of business ecosystem with a focus on spatial (geographical) context. Further, the aim is to define evolution and change dynamics of business ecosystems and address the change drivers and barriers of business ecosystems in health and life sciences industry.*

Design/methodology/approach: *This study is based on the literature findings on business ecosystems, spatial innovation, and characteristics of health and life sciences industry.*
Findings: *The literature findings and analysis provide a research frame that will be utilized in forthcoming empirical studies.*

Research limitations/implications: *This paper is based on literature findings. Furthermore, the study mainly focuses on business ecosystems in spatial context and health and life sciences industry. The research frame may also be applied to other contexts. Future research should address the validity of the research frame via empirical studies in different types of contexts.*

Practical implications: *The frame developed in this paper enables researchers to conduct systematic empirical research on business ecosystems and underlying phenomena.*

Originality/value: *Literature on business ecosystems originates from 1990's, and the research is relatively immature. While several studies on business ecosystems have been carried out, they have mostly focused on software and Information and Communications Technology (ICT) industries. This study provides new insights into business ecosystem concept in a novel context.*

Article classification: Research paper

INTRODUCTION

Developed countries are seeking new sources of growth due to the erosion of traditional industrial clusters and as they face knowledge-based competition from an increasing number of rapidly developing countries. Meanwhile, fast emerging and converging technologies combined with accelerating globalization, are creating a very complex operating environment for companies, policymakers and other stakeholders. Competition is shifting from company and industry levels towards a business ecosystem level.

With the business ecosystem we mean constellations of companies and other stakeholders which are tied together through knowledge flows and shared value creation processes (Moore, 1993; Iansiti and Levien, 2004a). The preceding concepts, such as *clusters* and *value chains* (e.g. Porter, 2000), have received a lot of attention over the years. Yet, despite being popular, the cluster concept has also received increasing criticism that includes, for example, the inability to explain the underlying factors that contribute to the success of certain geographical locations (Kim, 2013). Business ecosystem concept, in turn, can offer insights into the change dynamics and related strategic consequences across industries (Makinen and Dedehayir, 2012).

Business ecosystems are typically considered to be global in nature and span over geographical locations. However, as competition between regions and countries has increased, it is vital to understand the business ecosystems phenomenon also in its spatial (geographical) context. For this purpose, we apply Carayannis and Campbell's (2009) definition of spatial clusters which are considered to represent a certain geographic, spatial configuration, tied to a location or a larger region. In this context proximity is seen important, as it enhances, for example, knowledge sharing and exchange.

Health care and life sciences involve various public and private actors that are in the business of contributing to people's health. Health and life sciences are seen of high importance and potential for future competitiveness and sustainable growth in many countries. On the other side,

countries with an ageing population face growing cost pressures in their health care systems. This is becoming a difficult socio-economic problem in most welfare societies. In an increasingly uncertain and complex global economy, we need to understand the phenomenon of evolving business ecosystems also beyond software and ICT industries, which have been the main focus of the past research. Furthermore, this understanding should cover not only companies, but also actors in public sector including their roles and relationships. Our aim in this study is to construct a research frame applicable to study the ecosystem phenomenon in health and life sciences industry and in spatial contexts. Accordingly, this paper addresses the following research questions:

1. *What dynamic and evolutionary mechanisms impact business ecosystems?*
2. *What key conditions facilitate growth and innovation in business ecosystems in spatial context?*
3. *What are the change drivers and barriers in health and life sciences business ecosystems?*

The answers lay the ground to study business ecosystems in health and life science industry, as they are further synthetized and constructed into a research frame for further studies. This paper is based on literature search, review, analysis and synthesis, and uses a constructive research approach leading to the aforementioned research frame. Reviewed literature includes concepts and models of business ecosystems, dynamics and evolutionary mechanisms of business ecosystems, and respective drivers and barriers characterizing the ecosystems. The main context is the health and life science industry.

BUSINESS ECOSYSTEMS AND INNOVATION IN SPATIAL CONTEXT

Scientific literature around the term and concept of business ecosystem is relatively novel. In fact, 95 of 101 documents in Scopus citation database (accessed April 4th, 2014) found by using the search term "business ecosystem" in title, abstract and keywords in the subject area of business and management, published since 2007. Correspondingly, search term "innovation ecosystem" results in 51 documents, of which 41 are published since 2010.

The business ecosystem term was introduced in the literature by Moore (1993) and reinvented by Iansiti and Levien (2004a). These seminal works along with Teece (2007), Santos and Eisenhardt (2005), Adner (2006), and Adner and Kapoor (2010) form the most established body of that literature, followed by series of empirical and conceptual studies. Naturally, the underlying phenomenon of business ecosystems has been studied in more specific domains, such as mobile or digital ecosystems (Basole, 2009; Corallo *et al.,* 2007), transportation (Leviäkangas *et al,.* 2014), in restricted research subjects and different network concepts and terminologies, as

shown e.g. in Majava *et al.* (2013). Business ecosystem and innovation ecosystem are becoming established as distinctive terms and concepts in scientific business and management literature.

Business ecosystem: concept, evolution, and change dynamics

A major advantage of the business ecosystem concept over other network frameworks is claimed to be its ability to consider the change dynamics and related strategic consequences, which can be very valuable for the ecosystem members (Makinen and Dedehayir, 2012; Moore, 1993). In their study of main characteristics of business ecosystem, business network, business cluster, triple helix, keiretsu, and innovation hub concepts, Majava *et al.* (2013) emphasize that innovation and coevolution are the main sources of change dynamics in the business ecosystem.

Business ecosystem life-cycle includes four stages: birth, expansion, leadership, and self-renewal or death. Innovations are the key in every stage of the lifecycle: ecosystem births form around new innovations, incremental innovations enable growth, and renewals or deaths are caused by new innovations. During the self-renewal stage dominant companies may try to slow the growth of a new ecosystem or they may attempt to blend new innovations into their own ecosystem. A fundamental restructuring may also occur during the self-renewal stage (Moore, 1993).

Business ecosystems develop through self-organization, emergence and coevolution (Peltoniemi and Vuori, 2004). In business ecosystems, companies develop mutually beneficial relationships with customers, suppliers, and competitors (Iansiti and Levien, 2004a). The companies coevolve capabilities around a new innovation: they cooperate and compete to support new products, to satisfy customer needs, and finally to build succeeding innovations. Other actors adjust to the rules set by the lead actors (also known as keystones or platform leaders) who may change over time. However, the ecosystem community values the leaders that enable the members to move toward a shared future and benefits (Iansiti and Levien, 2004a; Moore, 1993; Moore, 1996). The rules in the ecosystem result from the coevolution and interactions between the participants. Besides competitive forces, constraints are set by the regulators and legislation, standard-setting bodies, social norms, and business ethics (Teece, 2007).

Makinen and Dedehayir (2012) argue that keystone firms have a vital role in business ecosystem design compared to its other members, such as supporting niche players and various intermediaries. In addition, the level of control assumed by a keystone firm is a significant factor that affects the ecosystem internally. External factors affecting the ecosystem, in turn, include changes in social, economic, technological, and competitive environment. Furthermore, bottlenecks, which constrain value creation, motivate innovation that causes changes in the ecosystem.

Business ecosystem term is based on evolutionary biology, which explains why 'evolution' and 'change dynamics' are often used in the context of business ecosystems. According to Encyclopedia Britannica (2014), evolution is "a process of change in a certain direction" allowing the originally biological term to be applied in practically all contexts studying change. Blijleven *et al.* (2013) propose an approach where central concepts of evolutionary biology are translated to their evolutionary economic equivalents, i.e. inheritance equals routines, selection equals competition, and variation (mutation) equals innovation. On the other hand, dynamics has many definitions depending on the context where it is used. For example, dynamics can be defined as "the branch of mechanics concerned with the motion of bodies under the action of forces" (Oxford Dictionaries, 2014a).

In this paper, the term evolution is used when discussing long-term development in the ecosystems, whereas dynamics refers to shorter-term interactions and changes within and between ecosystems. Dynamics in business ecosystems can also be considered from perspectives of relationships between actors and the ecosystems' influences over another. The boundaries with competing and converging ecosystems may not be clear, and regional business ecosystems exist within global business ecosystems. This is illustrated in Figure 1.
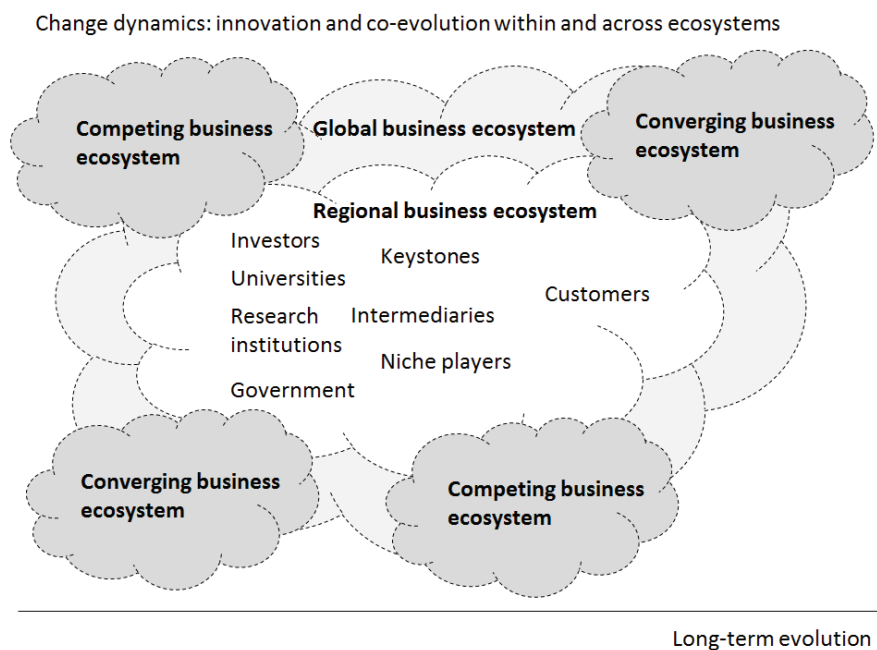
Figure 1. Change dynamics and evolution within and across ecosystems.

Business ecosystems have been modelled in several studies. First Moore (1996) proposed a generic model where actors are classified into three levels based on the extent of business

relations: core business, extended network and business ecosystem. Each level contains four different groups of actors; for example, business ecosystem level includes competing companies and related industries as well as government, and stakeholders such as owners, investors and trade associations (Moore, 1996). This generic model serves as explaining who are involved in business, but it does not offer practical utility to capture evolution of specific ecosystems or co-evolving relations between the actors. Similarly, Basole's (2009) static analysis of the converging mobile ecosystem visualize who are involved and connected to each other, highlighting the focal companies, but it does not offer insight into the dynamics of ecosystems.

Battistella *et al.* (2013) developed more elaborated network analysis and modelling tool to study the static structure of digital imaging ecosystem and proposed foresight methodologies for analyzing ecosystem dynamics and evolution. Their contribution and discussion focuses more on tool issues, which can be seen especially in their selection of relationship types between ecosystem actors: no relationship, tangible, intangible, or possible future relationship. Thus, dynamic and co-evolutionary mechanisms between actors are dismissed also in their modelling.

Adner and Kapoor (2010) used generic schema of an ecosystem which identifies four different types of actors: suppliers, focal firm, complementors, and customers. Adner and Kapoor (2010) address the ecosystem evolution by analyzing the effect of external innovations to focal companies and component and complement challenges across nine technology generations in the global semiconductor lithography equipment industry. Modelling global business ecosystems, which can contain thousands of companies and dozens of different 'species', as seen e.g. in Microsoft driven ecosystem (Iansiti and Levien, 2004b), is needed to visualize the existence of inter-firm relations and explain long term evolution. However, this type of modelling does not reveal change dynamics or co-evolving relations between the actors. Thus, it is necessary search those from more focused fields of literature.

Innovation in business ecosystems and spatial contexts

Innovation is arguably the most important contributor to the ecosystem growth. Therefore, it is important to understand different factors accelerating innovation. These factors can be considered from various perspectives. Makinen and Dedehayir (2012) stress that bottlenecks which constrain value creation, are the major innovation motivators within an ecosystem. Bossink (2004), in turn, presents four innovation driver categories in construction networks: environmental pressure, technological capability, knowledge exchange, and boundary spanning. Hwang and Horowitt (2012) emphasize diversity of talents, trust across social barriers, motivations that rise above short-term rationality, and social norms that promote rapid collaboration and experimentation. In their view, innovation ecosystems are biological systems – talent, ideas, and capital are the nutrients moving through the system. Creative destruction alone is not sufficient, creative reassembly is considered to be more important. On the other hand,

innovativeness and success of certain geographical regions can be viewed from three different perspectives: having universities as anchors of regional clusters, social networks as enabling factor, and institutional frameworks (Casper, 2013).

Innovations require suitable environmental conditions (Trott, 2012). From the spatial point of view, these conditions include, for example, adequate basic research, "angels" willing to invest, talented people, and capital (Suh, 2010). On the other hand, triple helix type of collaboration between academia, industry and government is claimed to accelerate innovations and creation of new organizations and institutions, such as incubators and venture capitalists (Etkowitz and Leydesdorff, 1997; Mok, 2012). Thus, many countries and regions are trying to achieve an innovation environment that includes university spin-offs, initiatives for knowledge-based economic development, and boundary-spanning and partnerships between companies, government laboratories, and academic research groups (Etkowitz and Leydesdorff, 2000). These efforts are naturally combined with other policy instruments, such as accessible risk capital and R&D subsidies.

The initiatives to support innovation creation also include legislation changes, financial support, entrepreneurial development, and establishing new foundations, organizational forms and programs (Etkowitz and Leydesdorff, 2000; Youtie and Shapira, 2008). Launonen and Viitanen (2011) also stress the importance of a holistic innovation environment; this is considered to include public policy activities, public-private partnerships (PPP)-driven activities, and company-driven activities. The first element contains innovation policy, infrastructure and service structures, and education and training. The second element consists of comprehensive R&D systems, cluster policies and programs, test-beds and living labs, and incubation environments. The third element covers the creation of successful start-ups and SME growth, and dynamic anchor companies that enable access and growth.

San Diego as an example of spatial context for growing business ecosystems

San Diego can be considered as a region with an innovation-friendly environment that has nurtured growing business ecosystems, especially in wireless technologies and life sciences. The region started to focus on R&D already in 1960s supported by federal government investments in military and health. Research institutions provided critical mass of R&D capacity in mid-1980's and attracted international firms and venture investors. In addition, three pioneer start-up companies, Linkabit (wireless), ISSCO (computer graphics), Hybritech (biotechnology), played a key role. Starting from 1980s, intermediary organizations, such as CONNECT, started to emerge and accelerate innovation. In terms business culture, the role of trust and openness is often emphasized. San Francisco Bay area provided the needed access to capital to enable growth (Walshok and Shragge, 2014). The region also benefitted from enterprise-friendly policy changes, sound and transparent laws governing real estate, intellectual property, contracts, and

corporations, low-enough taxes, low-cost of setting up a new corporation, network of people with experience in science, technology, business, law, finance, and accounting, and ability to attract competent immigrants around the world (Hwang and Horowitt, 2012).

Walshok and Shragge (2014) argue that San Diego's success is based on five critical factors. These include natural advantage of place, values of early settlers, organizing communities for economic promise, the resources and talents the community cultivates, and how citizens define and promote their place. Furthermore, San Diego civic culture is characterized by risk-orientation, entrepreneurial talent, integrative civic platforms, multiple gateways to develop ideas and opportunities, and a culture of reinvestment. On the other hand, in a study of San Diego biotechnology cluster Kim (2013) states that the emergence and success of the cluster "are rooted in a dynamic environment of learning and engagement: (1) a mass of startups and small companies, which enabled and in some respects forced employees to learn the entire process of the biotechnology business; (2) constant inflows of talent from outside San Diego, which complemented and supplemented the local knowledge stock and practices; and (3) networking and communication opportunities provided by trade associations and research institutions and facilitated by the geographic density of the local environment." These three factors have enhanced learning processes in the region, and "to a large extent, the emergence of the San Diego biotechnology community was a process of creating and circulating local knowledge and practices" (Kim, 2013).

HEALTH AND LIFE SCIENCES & INNOVATION

Defining health and life sciences

The life sciences are "sciences concerned with the study of living organisms, including biology, botany, zoology, microbiology, physiology, biochemistry, and related subjects" (Oxford Dictionaries, 2014b). Advances in biotechnology and molecular biology have resulted in increasing specializations and interdisciplinary fields in the life sciences. For instance, biotechnology has its roots in 6000 B.C. when Sumerians and Babylonians started fermenting a kind of beer; starting from 20th century biotechnology has begun to provide various new applications in food, chemical, pharmaceutical, and energy fields (Kenney, 1986). The health sciences, in turn, can be considered as a life sciences' branch, which covers all areas of medicine and medical sciences and contains several sub-disciplines that apply science to health (Wikipedia, 2014).

Rising health care costs are a major issue in many countries. For example, EU health care spending ranges between 5 and 11 % of regional GDP and in the US the corresponding figure is approximately 16 % (Blank *et al.*, 2013; Herzlinger, 2006). Increasing costs, demographic changes, and the fact that the health care industry can greatly benefit from advances in life

sciences have resulted in a growing interest in increasing cooperation between the different sectors in health and life sciences. Furthermore, a paradigm shift, where health care is no longer viewed as a financial burden but as a driver of a competitive and knowledge-based health economy, is claimed to have occurred (Blank *et al.*, 2013). Recent developments, such as the foundation of European Connected Health Alliance and Wireless-Life Sciences Alliance, showcase the convergence of health and life sciences with other industries; especially information technology is considered as a key innovation driver (European Connected Health Alliance, 2014; Omachonu and Einspruch, 2010; Wireless-Life Sciences Alliance, 2014).

Considering the aforementioned and the complexity and fragmentation of health care systems and markets (Blank *et al.*, 2013), it is difficult to set exact boundaries for health and life science ecosystem. Health care related organizations also serve many purposes including prevention, diagnosis, treatment, education, research, and outreach (Omachonu and Einspruch, 2010). Thus, our definition of health and life science ecosystem includes all public and private actors that are in the business of contributing to human health. These include various companies offering products and services related to, for example, biotechnology, biomedicine, diagnostics, pharmaceuticals, medical devices, healthcare provision, supporting services, healthcare IT, connected and wireless health, and health tourism. In addition, the ecosystem includes universities, research institutions, and various intermediaries such as innovation catalyzers, incubators, trade organizations, angel investors, and venture capital firms.

The ecosystem complexity is further increased by governmental involvement and vast political interests related to it. A recent example of this is the process of creating and implementing the Affordable Care Act (Obamacare) in the US (Zwelling and Kantarjian, 2014). Hence, the obvious conclusion is that the drawing of boundaries of "health and life science ecosystem" is entirely contingent and must be done for each specific objective, case and task at hand.

Innovation in health and life sciences

Health related innovations can take place in various ways. Omachonu and Einspruch (2010) define health care innovation as "the introduction of a new concept, idea, service, process, or product aimed at improving treatment, diagnosis, education, outreach, prevention and research, and with the long term goals of improving quality, safety, outcomes, efficiency and costs." Herzlinger (2006), in turn, argues that three types of innovations can improve health care and reduce its costs: change the ways consumers buy and use health care, utilize technology to develop new products and treatments or improve care, and generate new business models - especially ones that involve horizontal or vertical integration of separate health care organizations or activities. On the other hand, the latter two, business model and technology

design, have also been found to be strongly interrelated in health related ventures (Lehoux *et al.*, 2014).

Despite the innovation potential and related benefits, innovation in health care is difficult due to several reasons. First of all, a number of powerful stakeholders including health care providers, doctors, patients, and regulatory agencies must support the new innovation (Herzlinger, 2006; Omachonu and Einspruch, 2010). Second, research intensiveness, long development and approval cycles, and third-party payment system (e.g. government or private insurer) make innovation funding different from most other industries (Herzlinger, 2006). For instance, due to the large amounts of capital required to get the products to market, angel investors often favor investing in technologies with faster market access (e.g. software or IT). Less capital-intensive development, such as diagnostics or medical devices, is preferred over drug discovery and development (Global Connect, 2010). The third major issue involves policy; regulators tend to avoid risks associated with approving new health related innovations. Fourth, timing of investing and adopting new technology is difficult; the new technology typically requires supporting infrastructure, but one cannot wait too long as competition exist both within and across technologies. For instance, a vaccine can eliminate demand for certain drugs and treatments. The fifth key issue has to do with customers. Consumers have become increasingly aware of different options available, and they may either embrace or reject new innovations. Sixth, increased accountability is required. In addition to regulators' short-term efficacy and safety requirements, health care innovators must simultaneously fulfil long-term cost effectiveness and safety to consumers and third-party payers (Herzlinger, 2006).

Blank *et al.* (2013) highlight the following health innovation barriers: complexity of the environment and systems, fragmentation and independency of different actors, fragmentation of research & development efforts, inadequate financing, high IPR costs, slow standardization, ineffective user of public procurement, inadequate support for SMEs, and inadequate utilization of health care professionals and their lack of entrepreneurial and commercialization competences.

The funding system also affects innovation incentives. For instance, the US health care system is based on the coverage provided by medical insurance companies (Zwelling and Kantarjian, 2014). In Europe, the Nordic countries and Latvia have implemented state-financed system giving free health care access to all citizens (Beveridge system), whereas Germany, Poland, and Estonia utilize so-called Bismarck system financed by social security contributions from the insured employees and their employers (Blank *et al.*, 2013). Herzlinger (2006) argues that the single-payer system may hinder customer-focused and technology-based innovations, because the need to control costs results in less spending on seriously ill patients, who are the target of most technology-based innovation. This can also be the reason why a large venture-

capital community does not exist in Europe to fund new health technology ventures. Centralized health care systems control prices and reduce margins for innovators. The centralized systems provide innovation potential in the treatment of diseases requiring a lot of integration, but the results have been mixed.

SYNTHESIS AND RESEARCH FRAME

Past literature on business ecosystems has mostly focused on software and Information and Communications Technology (ICT) industries. This study provides new insights into business ecosystem concept, also beyond the aforementioned industries. The study creates a research frame that can be utilized to research the ecosystem phenomenon in health and life sciences in spatial contexts. This is done by discussing and analyzing literature findings on business ecosystems, the dynamics and evolutionary mechanisms that impact them, the key conditions facilitating growth and innovation in business ecosystems in spatial context, and exploring the change drivers and barriers in health and life sciences business ecosystems. The key findings are presented in Table 1.

Table 1. Research key findings and synthesis.

Structural elements of business ecosystems
Actors
Private, public, and non-governmental organizations (NGOs)
which can also be classified into
Lead actors (keystones), niche players, and intermediaries
Platform(s)
Regional coverage
Change dynamics and evolution
Evolution (long-term)
Social, economic, political, regulatory, competitive, and technological changes
Life-cycle stage: birth, expansion, leadership, self-renewal or death
Dynamics (short-term)
Innovation
Component innovations
Complementing innovations
Competing and substituting innovations
Co-evolution
Collaboration and competition among various actors
Self-organization, rules and constraints set by lead actors, competitive forces, regulators, laws, norms, and ethics
Interaction with competing and converging ecosystems

Innovation enablers in spatial context	Change factors in health and life sciences
Resources	Drivers
Capital	Rising health care costs
Talent	Demographic changes
Available networks	Rapid advances in life sciences
Adequate research activities	Technology convergence
Culture	Barriers
Social norms	Fragmentation and complexity of the systems and markets
Trust	Numerous influential stakeholders
Cooperativeness to support knowledge exchange and boundary spanning	Fragmented research efforts
Entrepreneurial culture	Inadequate financing
Government support	Long R&D and approval cycles
Adequate infrastructure	IPR costs
Research funding	3rd party payment system
Enterprise-friendly policies and programs	Slow standardization
	Risk-avoiding policies
	Ineffective use of public procurement
	Insufficient support for SMEs
	Inadequate use of health professionals and lack of their business competences

As Table 1 illustrates, various considerations are involved in studying health and life sciences business ecosystems in spatial contexts. The structure of business ecosystem includes actors, platform(s), and regional coverage considerations. Change dynamics and evolution, in turn, involve the short-term and long-term mechanisms that impact the business ecosystem. Innovation enablers in spatial context are also relevant; these can be classified into factors related to resources, culture, and government support. In addition, table 1 points out many influential factors driving change in health and life sciences ecosystems. However, several change barriers also exist, which hinder new innovations. Relevant research questions for future study purposes include:

- How different actors facilitate and support innovation and growth in spatial business ecosystems?
- How global business ecosystems adapt and use local settings to catalyst their innovation, competitiveness and growth?
- What are the most significant innovation barriers in health and life sciences business ecosystems and how should they be addressed?

Due to the complexity of business ecosystem phenomenon, a research strategy that involves case study approach is proposed. Multiple data collection methods including theme and semi-structured interviews must be utilized. The interviews should be conducted among informants

with in-depth information on the ecosystem under study. Relevant interview questions include the following:

- Who are the main actors and what are their roles in the ecosystem? How have the roles of the main actors changed through the years?
- What types of relationships exist between actors? How have these relationships changed through the years?
- What are the main characteristics of the ecosystem – spatially and globally?
- How the spatial ecosystem is connected to a global ecosystem and vice versa?
- What is / are the platform(s) of the ecosystem? How has the platform changed through the years?
- Who provides the platform, defines the architecture, and sets the rules?
- What is the role of healthcare providers, universities, and research institutions in the ecosystem?
- How relevant is public funding, programs, or policies for the ecosystem?
- What is the role of intermediary organizations?
- What factors drive the ecosystem growth?
- What factors are barriers for the ecosystem growth?
- What is the role of trust in the ecosystem?
- How will the ecosystem evolve in the future?
- What will change during the next years?

The research frame described above provides the basis for empirical studies of health and life science business ecosystems in selected spatial contexts. The frame aims to enable researchers to conduct systematic empirical research on business ecosystems and underlying phenomena. However, it should be noted that due to the complexity of the phenomenon under study, the research frame developed in this paper cannot considered to be final and will be refined iteratively during the research project. It must also be noted that this paper is based solely on literature findings. While the study focuses on business ecosystems in spatial context and health and life sciences industry, the research frame can also be utilized in other contexts. Thus, further research is recommended to test the validity of the research frame via empirical studies in different types of contexts.

ACKNOWLEDGEMENTS

REFERENCES

1. Adner, R. (2006), "Match your innovation strategy to your innovation ecosystem", *Harvard Business Review*, Vol. 84, No.4, pp. 98–107.

2. Adner, R. and Kapoor, R. (2010), "Value creation in innovation ecosystems: How the structure of technological interdependence affects firm performance in new technology generation", *Strategic Management Journal,* Vol. 31, No. 3, pp. 306–333.

3. Basole, R.C. (2009), "Visualization of interfirm relations in a converging mobile ecosystem", *Journal of Information Technology,* Vol. 24, pp. 144-159.

4. Battistella, C., Colucci, K., De Toni, A.F. and Nonino, F. (2013), "Methodology of business ecosystems network analysis: A case study in Telecom Italia Future Centre", *Technological Forecasting & Social Change,* Vol. 80, pp. 1194-1210.

5. Blank, W., Frank, P., and Karopka, T. (2013), "Health and life sciences as drivers for regional development and prosperity in the Baltic Sea Region", *Journal of East-West Business*, Vol. 19, No. 1-2, pp. 122-137.

6. Blijleven, V., van Angeren, J., Jansen, S. and Brinkkemper, S. (2013), "An evolutionary economics approach to ecosystem dynamics", *Digital Ecosystems and Technologies (DEST), 2013 7th IEEE International Conference on Digital Ecosystems and Technologies in Menlo Park, CA, USA, 24-26 July 2013*, pp. 19-24.

7. Bossink, B.A.G. (2004), "Managing drivers of innovation in construction networks", *Journal of Construction Engineering and Management*, Vol. 130, No. 3, pp. 337-345.

8. Carayannis, E. G. and Campbell, D. F. (2009), "'Mode 3' and 'Quadruple Helix': toward a 21st century fractal innovation ecosystem", *International Journal of Technology Management*, Vol. 46, No. 3, pp. 201-234.

9. Casper, S. (2013), "New-technology clusters and public policy: Three perspectives", *Social Science Information*, Vol. 52, No. 4, pp. 628-652.

10. Corallo, A. (2007), "The business ecosystem as a multiple dynamic network", in Corallo, A., Passiante, G. and Prencipe, A. (Eds.), *The digital business ecosystem*, Edward Elgar Publishing, Cheltenham, UK, pp. 11-32.

11. Encyclopedia Britannica (2014), "Evolution", available at: http://www.britannica.com/bps/dictionary?query=evolution (accessed 11 April 2014).

12. Etzkowitz, H. and Leydesdorff, L. (Eds.) (1997), *Universities and the Global Knowledge Economy: A Triple Helix of University–Industry–Government Relations*, Cassell Academic, London.

13. Etzkowitz, H. and Leydesdorff, L. (2000), "The dynamics of innovation: From National Systems and "mode 2" to a Triple Helix of university-industry-government relations", *Research Policy*, Vol. 29, No. 2, pp. 109–123.

14. European Connected Health Alliance (2014), "European Connected Health Alliance", available at: http://www.echalliance.com/ (accessed 12 March 2014)

15. Global Connect (2010), "Biotechnology cluster project San Diego Analysis", United States Studies Centre, University of Sydney, Australia.

16. Herzlinger, R. E. (2006), "Why innovation in health care is so hard", *Harvard business review*, Vol. 84, No 5, pp. 58-66.

17. Hwang, V.W. and Horowitt, G. (2012), *The Rainforest: The Secret to Building the Next Silicon Valley*, Regenwald, Los Altos Hills, California, USA.

18. Iansiti, M. and Levien, R. (2004a), "Strategy as Ecology", *Harvard business review,* Vol. 82, No. 3, pp. 68–78+126.

19. Iansiti, M. and Levien, R. (2004b), *The Keystone Advantage: What the New Dynamics of Business Ecosystems Mean for Strategy, Innovation, and Sustainability,* Harvard Business School Press: Boston, MA.

20. Kenney, M. (1986), *Biotechnology: the university-industrial complex*, Yale University, USA.

21. Kim, S. T. (2013), "Regional Advantage of Cluster Development: A Case Study of the San Diego Biotechnology Cluster", *European Planning Studies*, (ahead-of-print), pp. 1-24.

22. Launonen, M. and Viitanen, J. (2011), *Hubconcepts. The global best practice for managing innovation ecosystems and hubs*, Hubconcepts Inc., Finland.

23. Lehoux, P., Daudelin, G., Williams-Jones, B., Denis, J. L. and Longo, C. (2014), "How do business model and health technology design influence each other? Insights from a longitudinal case study of three academic spin-offs", *Research Policy*, (in press).

24. Leviäkangas, P., Aapaoja, A., Kinnunen, T., Pilli-Sihvola, E., Hautala, R. and Zulkarnain. (2014), "The Finnish Road Weather Ecosystem – Turning Societal Benefits into Business and the Other Way Round", *Engineering Management Research*, Vol. 3, No. 1, pp. 56-57.

25. Majava, J., Isoherranen, V. and Kess, P. (2013), "Business Collaboration Concepts and Implications for Companies", *International Journal of Synergy and Research*, Vol. 2 No. 1, pp. 23-40.

26. Makinen, S. J. and Dedehayir, O. (2012), "Business ecosystem evolution and strategic considerations: A literature review", *Engineering, Technology and Innovation (ICE), 18th International ICE Conference in Munich, Germany, 18-20 June 2012*, pp. 1-10.

27. Mok, K.H. (2012), "The quest for innovation and entrepreneurship: The changing role of university in East Asia", *Globalisation, Societies and Education*, Vol. 10, No. 3, pp. 317–335.

28. Moore, J.F. (1993), "Predators and prey: a new ecology of competition", *Harvard business review,* Vol. 71, No. 3, pp. 75–86.

29. Moore, J.F. (1996), *The Death of Competition: Leadership & Strategy in the Age of Business Ecosystems,* HarperBusiness, New York.

30. Omachonu, V. K. and Einspruch, N. G. (2010), "Innovation in Healthcare Delivery Systems: A Conceptual Framework", *Innovation Journal*, Vol. 15, No. 1, pp. 2-20.

31. Oxford Dictionaries (2014a), "Dynamics", available at: http://www.oxforddictionaries.com/definition/english/dynamics?q=dynamics (accessed 10 April 2014).
32. Oxford Dictionaries (2014b), "Life sciences", available at: http://www.oxforddictionaries.com/definition/english/life-sciences?q=life+sciences (accessed 10 April 2014).
33. Peltoniemi, M. and Vuori, E. (2004), "Business ecosystem as the new approach to complex adaptive business environments", *Proceedings of eBRF 2004 in Tampere, Finland*, 2004, pp. 267–281.
34. Porter, M.E. (2000), "Location, competition, and economic development: Local clusters in a global economy", *Economic Development Quarterly*, Vol. 14, No. 1, pp. 15–34.
35. Santos, F.M. and Eisenhardt, K.M. (2005), "Organizational Boundaries and Theories of Organization", *Organization Science*, Vol. 16, No. 5, pp. 491-508.
36. Suh, N.P. (2010), "A theory of innovation and case study", *International Journal of Innovation Management*, Vol. 14, No. 5, pp. 893–913.
37. Teece, D.J. (2007), "Explicating dynamic capabilities: The nature and microfoundations of (sustainable) enterprise performance", *Strategic Management Journal,* Vol. 28, No. 13, pp. 1319–1350.
38. Trott, P. (2012), *Innovation Management and New Product Development*, Pearson Education Limited, Harlow, UK.
39. Zwelling, L. and Kantarjian, H. M. (2014), "Obamacare: why should we care?", *Journal of Oncology Practice*, Vol. 10 No. 1, pp. 12-14.
40. Walshok, M. and Shragge, A. (2014), *Invention and Reinvention: The Evolution of San Diego's Innovation Economy*, Stanford University Press, Stanford, California.
41. Wikipedia (2014), "Life sciences", available at: http://en.wikipedia.org/wiki/Life_sciences (accessed 12 March 2014).
42. Wireless-Life Sciences Alliance (2014), "Wireless-Life Sciences Alliance", available at: http:// http://wirelesslifesciences.org/ (accessed 12 March 2014).
43. Youtie, J. and Shapira, P. (2008), "Building an innovation hub: A case study of the transformation of university roles in regional technological and economic development", *Research Policy*, Vol. 37, No. 8, pp. 1188–1204.

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IDENTIFYING INNOVATION CLUSTERS: THE SOCIAL NETWORK APPROACH

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STRUCTURED ABSTRACT

Purpose: Networking between stakeholders has been recognized as a very important element for fostering the innovation processes. In Slovenia, the government encourages the cooperation between organisations with three types of networking mechanisms: Competence Centres, Centres of Excellence, and Development Centres. With the information obtained from the membership in the networking mechanisms' we constructed a network of organisations. Research and development performance of each organisation was compared with its position occupied in the network. In the paper, we instructively provide the methodology which was used to i) establish the innovation one-mode network ii) obtain the innovation clusters, and iii) classify all actors-units (organisations) in the resulting clusters.

Design/methodology/approach: Networking mechanisms and organisations included in these mechanisms generate two-mode network. First mode consists of organisations and the second mode contains networking mechanisms. Various network analytic techniques and approaches are applied in the study, such as normalisation of weights on links, the notation of (generalized) cores, hierarchical clustering and similar. Special emphasis was on graphical presentations of networks obtained from the dataset. We used both types of network presentations: node-link display and matrix representation.

Findings: The most important Slovenian organisations in the field of innovation and knowledge production are revealed in the study. Furthermore, significant links between these organisations are identified. Results suggest two important indicators, regional affiliation and industrial sector to which observed organisation belongs. From methodological point of view, we confirmed that network analysis can serve as a powerful tool for detection of innovation clusters of organisations.

Research limitations: The most important limitation is that the analysis was carried out on Slovenian organisations, exclusively. Nevertheless, the methodology and network approaches applied in the paper can serve as a pattern for similar analysis in other countries.

Originality/value: The study represents one of the first attempts to apply network analytic techniques to study the impact of networking on innovation in Slovenian organisations. Moreover, interesting comparisons between countries are possible.

Keywords: network analysis, innovation clusters, Slovenia,

Type of paper: Research paper

INTRODUCTION TO SOCIAL NETWORK THEORY AND
LITERATURE REVIEW

A formal definition of a (social) network was set almost two decades ago by Wasserman and Faust (1994, p. 20): *A social network consists of a finite set or sets of actors and the relation or relations defined on them.* However, the first concepts of social network analysis were developed already in 1930s with Moreno (1934). He proposed the notion of *sociograms*, the graphical representations of relations between individuals. Individual units were displayed by points and relations by lines. In Figure 1 an example of the sociogram showing the attraction between pupils in a fourth grade class is presented (Moreno, 1934, page 38).
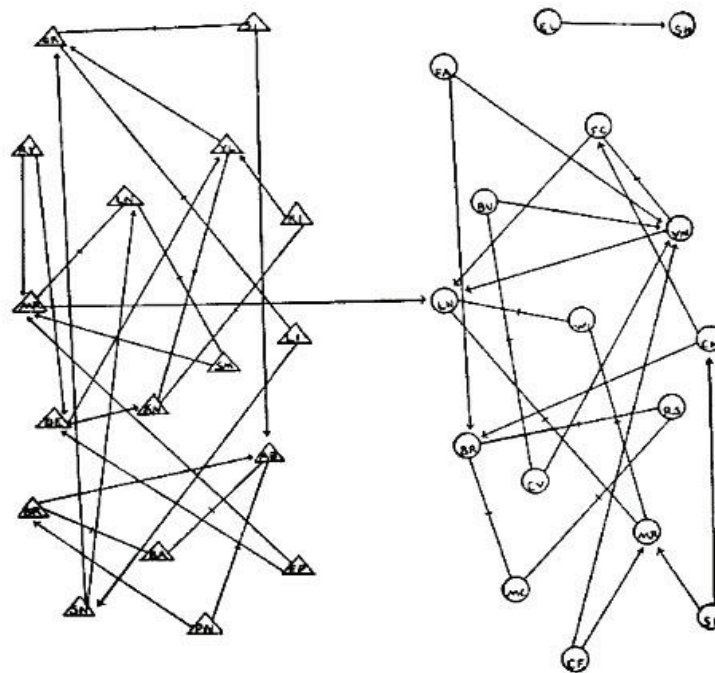
Figure 1: An attraction network in a fourth grade class (source: Moreno, 1934, page 38)

Moreno's sociograms were the starting point for graph theory, a mathematical approach to networks applied by Cartwright and Harrary (1956). Their contribution formalises the initial insight created by Moreno's sociograms. Nowadays, the social network analysis can be handled as a specific application of graph theory in which individual units such as social actors, groups and organisations are represented by points and their social relations are represented by lines (Hanneman and Riddle in Scott and Carrington, 2011).

In contrast to the standard statistical methods the social network analysis is not only concerned with quantitative results but also with the identification and the process of emerging and/or disappearing of linkage between actors. Wasserman & Faust (1994) argued that social network analysis employs a unique measurement approach, distinctive from other perspectives, by providing formal definitions of the structural elements that exists within networks. They further explained that network concepts are quantified by considering the relations measured among actors.

Beside graphs social network analysts use matrices to represent information about patterns of ties among social actors (Hanneman and Riddle in Scott and Carrington, 2011). Matrices are extremely helpful when larger and denser networks are being explored. Moreover, to gain an insight into a dense network at the level of the individual entity a matrix representation is preferable. Applied clustering methods enable us to uncover the patterns inside a matrix, which are almost impossible to see using a graphic display. Similar to computing the layout for the node-link diagram, rows and columns in an adjacency matrix should be ordered carefully. If nodes are placed in an arbitrary order in the matrix it could happen that the matrix does not reveal the network structure. A reordering or sorting of nodes in the matrix, described by a permutation, is therefore an important issue. The aim is to find groups of similar actors and define their roles. Blockmodeling (Doreian et al, 2005) is a type of positional analysis which decomposes a matrix into blocks of different shapes. It uses one of many clustering methods or equivalence relations defined in a graph.

Cohesive subgroups in social network theory contain dense pockets of actors who "stick together" (de Nooy et al, 2012). The phenomenon that similar people interact a lot is called homophily: Birds of feather flocks together. Several methods can be applied to network to measure this process. On the level of a network, a density is a proportion between the number of lines in the network and the maximum possible number of lines. On the level of nodes, a degree of a node is the number of lines incident (incoming or outgoing links) with the node. Advanced methods as components and cores will be presented later where needed.

A two-mode network consists of two sets of nodes with the property that nodes from each of these two sets can only be related to nodes in the other set. Whereas sets are usually called actors and events, this type of network is known also as an affiliation network. Affiliation data in the literature include many examples, e.g. corporate board memberships, attendance at events, memberships of clubs, participation in online groups, authorship of articles, and others (Borgatti and Halgin, 2011). 'Two-mode network' is a more general term than 'affiliation', since the latter is reserved for some kind of membership network. Therefore, we will use the term two-mode network from now on. A classic approach to display two-mode data is with a bipartite graph. The set of companies and their board members is a classic example of a bipartite graph: individual board members sit on the boards of different companies (Antilla-Hughes and Hsiang, 2011).
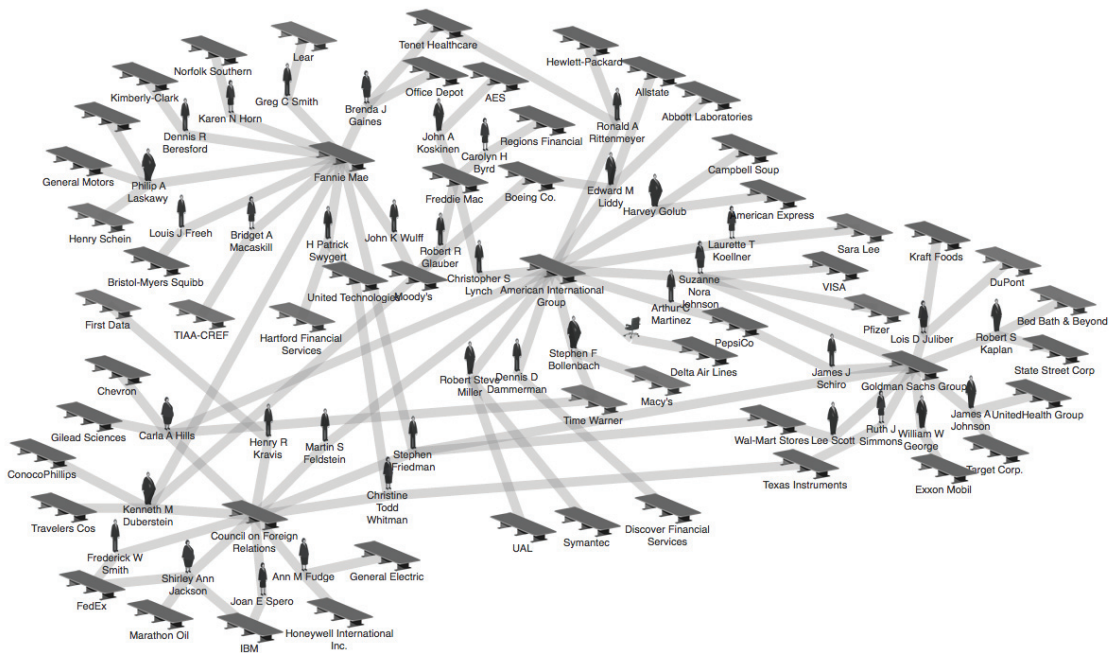
Figure 2: A bipartite graph of individual board members and boards of different companies (Antilla-Hughes and Hsiang, 2011)

EMPIRICAL STUDY OF INNOVATION CLUSTERS IN SLOVENIA AND DISCUSSION

Within the framework of scientific-technological policy of the Republic of Slovenia three mechanisms were created (Competence Centres, Centres of Excellence and Development Centres) to promote the concentration of knowledge in priority areas of technology and horizontal integration across the supply chain knowledge development. Their purpose is to support projects that include both development work and the necessary equipment and other infrastructure, which allows the development of enterprises, their competencies and long-term foundations for growth and economic development and will allow technological breakthroughs in the areas where Slovenia has a critical mass of knowledge (Ministry of Economic Development and Technology, 2013).

Participation of organisations in the centres can be considered as two-mode network – the first mode consists of organizations and the centres form the second mode. Individual organisation is not restricted to a specific centre, but rather may participate in many others as well. The basic network consists of 336 organisations (first mode) which are grouped in 34 centres (second mode).

If relation between organisations is defined as the number of times they participated in the same centre basic one mode-network can be obtained from two-mode network. Undirected

one-mode network consists of 336 organisations and 3697 edges among them. The vast majority of edges (3527 or 95.4%) has the value of 1, the remaining 170 edges are higher valued.

To identify the organisations with an increased tendency of collaboration the generalized cores method was used. The (sub)network of all 31 organisations which participate with other organisations from this (sub)network in at least 10 common centres was extracted. In other words, sum of the values of links for each organisation in the (sub)network is at least 10. Organisations in the (sub)network were further divided into four groups using Ward's method of hierarchical clustering and generalized Euclidean distance. Clustering is the task of segmenting a heterogeneous population into a number of more homogeneous groups or clusters. The dendrogram of clustering is displayed in Figure 3.
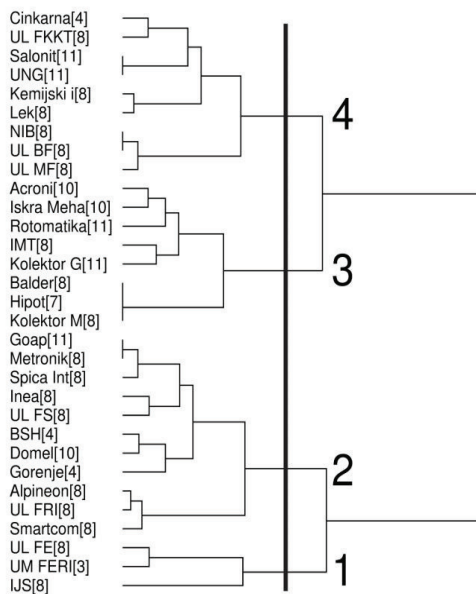
Figure 3: Dendrogram of clustering organisations in Slovenian centres

Matrix presentation of collaboration of 31 organisations in Slovenian centres is presented in Figure 4. Each organisation has its own row and its own column. Collaboration of each pair of organisations is displayed by the greyscale colour of the cell in the row of the first organisation and the column of the second organisation. Darker colour indicates more collaboration. The matrix is symmetrical since the network is undirected.

Three organisations in cluster 1 are most strongly connected as cells indicating collaboration among them are darkened. Cluster 1 consists of two high education institutions (Faculty of Electrical Engineering (UL FE) from University of Ljubljana and Faculty of Electrical Engineering and Computer Science (UM FERI) from University of Maribor) and a

research institute (Institut "Jozef Stefan" (IJS) in Ljubljana). Furthermore, IJS is connected with almost all organisations in Figure 4 and therefore recognized as the leading organisation in the area of research and development in Slovenia. As reported by (Dermol et al, 2013) the organisations in cluster 1 are the most innovative regarding the number patents and research work. Organisations in the cluster 2 are closely connected to organisations in cluster 1. Their background is computer engineering electronic communications and speech technology. Clusters 3 and 4 are more self-oriented. Organisations of cluster 3 are involved in electronic technologies and organisations in cluster 4 in pharmacy. Precise analysis of organisations in each of four clusters can reveal further interesting insights but it is beyond the scope of this section.
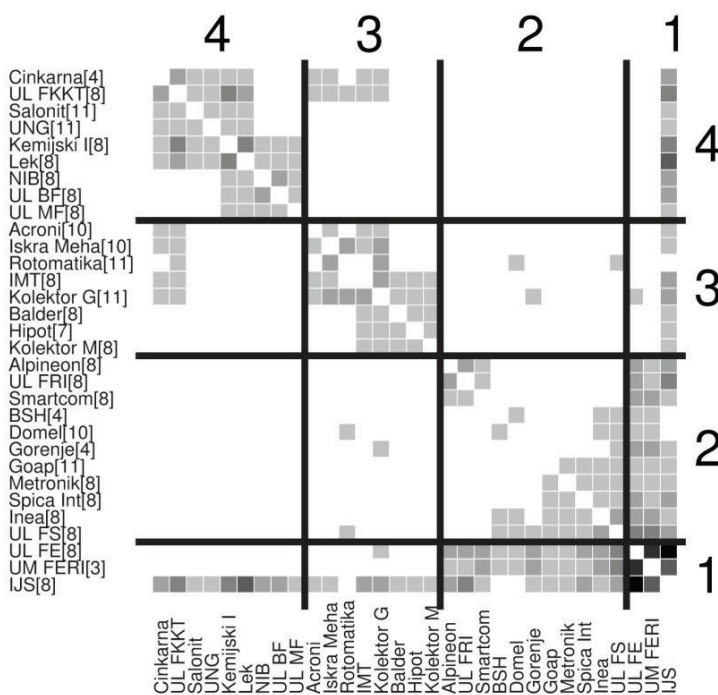
Figure 4: Matrix presentation of collaboration in Slovenian centres

Slovenia consists of 12 statistical regions. By shrinking all organisations in basic one-mode network into a region of origin we obtained undirected network of collaboration between Slovenian regions. Some regions are represented with more organisations than others. To relativise the impact of regions' size we divide weights on links by the square root of a product between the numbers of organisations in both incidence regions. Graphical display of compressed network where nodes are representing regions and links relative collaboration between them is presented in Figure 5.

Circle shape nodes are used for regions from western Slovenia and box shape is used for eastern part. The size of each node (representing the region) is proportional to the number

of organisations in the region. Nodes representing Central Slovenia region and Podravska region are the largest as the highest number of organisations in Slovenia are concentrated in two largest Slovenian cities, Ljubljana (Central Slovenia region) and Maribor (Podravska region).

The (normalised) strength of links between nodes is indicated by its size and colour on the greyscale. The most important link is connecting nodes representing Central Slovenian region and Gorizia region. Graphic display of regions' network in Figure 5, clearly demonstrate the central role of Central Slovenian region.
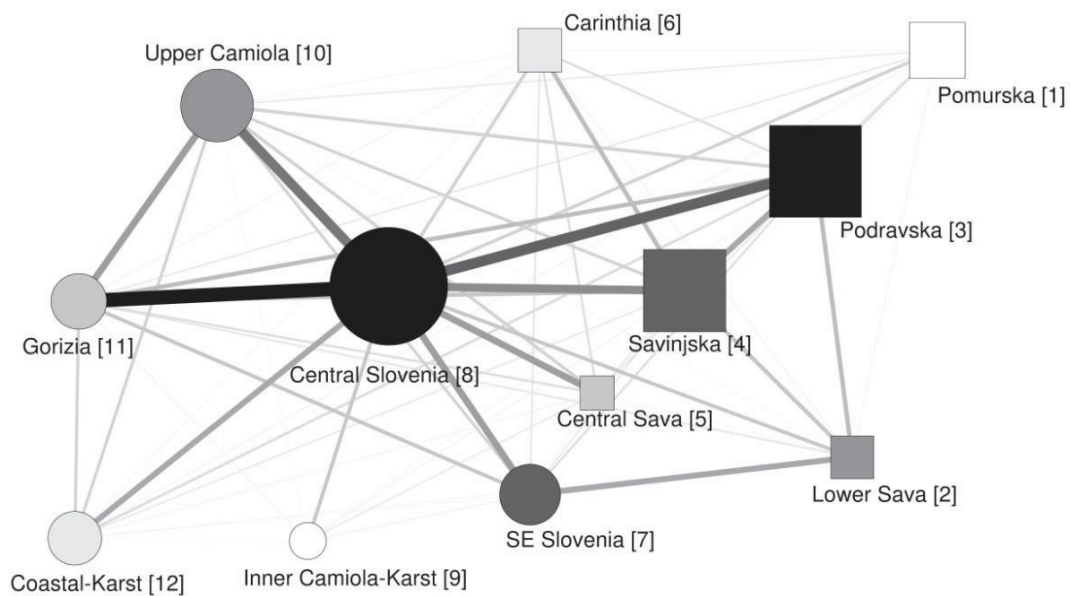
Figure 5: Shrinked display of collaboration of organisations in Slovenia on the regional level

CONCLUSIONS

This article provided a new research direction of applying social network methods for identifying innovation clusters. It aims to acknowledge social network analysis as useful technique in the field of economical and organisational management. Through an empirical study, the results indicated social network analysis and its specific concepts as a helpful concept for identification of units with high collaboration tendency. Moreover, social network analysis has the ability to identify the relationships that exists within the social structure and that is a powerful tool.

Specifically, we studied the collaboration of organisations in Slovenia on two levels. First, a collaboration of organisations in three types of centres for innovation was examined:

Competence Centres, Centres of Excellence and Development Centres. Groups of organisations with the highest tendency for collaboration in these centres were identified and analysed. Second, on the regional level we recognized the most important regions.

REFERENCES

1. Antilla-Hughes, J. and Hsiang, S. (2011). "Fight Entropy: Networks of the Economic Elite", available at http://www.fight-entropy.com/2011/08/networks-of-economic-elite.html (accessed 13 January 2014).
2. Borgatti, S. P. and Halgin, D. S. (2011). Analyzing Affiliation Networks. In Scott, J, and Carrington, P. J. (Ed.), *The SAGE Handbook of Social Network* Analysis (pp. 417–433). London: SAGE.
3. Cartwright, D. and Harary, F. (1956). Structural balance: a generalization of Heider's theory. *Psychological Review*, 63, 277–293.
4. Doreian, P., Batagelj, V. and Ferligoj, A. (2005). *Generalized Blockmodeling*. Cambridge: Cambridge University Press.
5. Hanneman, R. and Riddle, M. (2011). A Brief Introduction to Analyzing Social Network Data. In Scott, J, and Carrington, P. J. (Ed.), *The SAGE Handbook of Social Network* Analysis (pp. 331–339). London: SAGE.
6. Ministry of Economic Development and Technology, Republic of Slovenia, available at http://www.mgrt.gov.si/si/delovna_podrocja/podjetnistvo_konkurencnost_in_tehnologija/razvojni_centri_slovenskega_gospodarstva/ (accessed September 23 2013).
7. Moreno, J. L. (1934). *Who shall survive?* Washington, DC: Nervous and Mental Disease Publishing Company.
8. de Nooy, W., Mrvar. A. and Batagelj, V. (2012). *Exploratory Network Analysis with Pajek, Revised and Expanded Second Edition.* Cambridge: Cambridge University Press.
9. Wasserman S. and Faust K. (1994). *Social Network Analysis: Methods and Applications.* Cambridge: Cambridge University Press.

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EARLY STAGES OF TECHNOLOGY - INTENSIVE COMPANIES - CASES IN CALIFORNIA

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ABSTRACT

Purpose : Numerous "stages" models have attempted to clarify management priorities during the early stages of business growth. However, more focused and context-specific studies are needed. This study seeks to clarify the early stages of technology-intensive companies in California. This study bridges the gap described above by answering the following research questions: What kind of early stages do technology-intensive companies face, based on recent empirical literature? How do the experiences of managers in early-stage technology-intensive companies relate to the assumptions of such stage frameworks in Californian contexts? What context-specific viewpoints should be considered when using stage frameworks in the Californian context?

Design/methodology/approach : In this retrospective multiple case study, we formulate a four-stage framework describing the early stages of technology-intensive companies, through nine case studies. We use the sequential incident technique (SIT) and semi-structured interviews for data collection. Three perspectives were analysed in each company studied for triangulation purposes: one from company management, one from operations management and one from marketing management.

Findings – *This study makes a preliminary test of the applicability of the framework and analyses context-specific viewpoints. It is necessary to recognise these viewpoints when using this framework in California.*

Research limitations/implications : *The research focus of this study is limited by the context studied, the nine cases and its focus on the three first phases of the framework. This limits the applicability of the results to other contexts.*

Practical implications : *The results of the study may be effectively used in intermediary organisations as a framework for predicting the early stages of technology-intensive companies.*

Originality/value : *Context-specific viewpoints and their effect on the early stages of companies have not been widely studied. This study takes context into account and provides new insights into the growth and management of technology-intensive companies in the studied context.*

Category: Research paper

Keywords: stages of growth; growth process; California; sequential incident technique; technology-intensive companies.

INTRODUCTION

The growth and development of firms have been studied extensively in the last few decades, and the literature in this area includes many perspectives, such as static equilibrium theories (see e.g. Coase 1937), stochastic models (see e.g. Gibrat 1931), transaction cost theories (see e.g. Williamson 1975), economics of growth theories (see e.g. Penrose 1959), resource-based theories (see e.g. Penrose 1959), evolutionary theories (see e.g. Nelson & Winter 1982), organisational ecology theories (see e.g. Hannan & Freeman 1977), strategic adaptation theories (see e.g. Sandberg & Hofer 1982), motivational theories (see e.g. McClelland 1961) and configuration theories (see e.g. Greiner 1972). Most of these perspectives are concerned with the factors leading to growth. However, configuration perspectives – or company lifecycle or stages of growth perspectives (see e.g. Muhos *et al.* 2010, Muhos 2011) – have instead attempted to clarify managerial challenges and priorities in the early stages of companies (see e.g. Churchill & Lewis 1983, Greiner 1972). These perspectives relate to what growth means for a company, and how to manage a growing company (see Davidsson & Wiklund 2006, Wiklund 1998). The growth configuration (or stages of growth or lifecycle) literature reveals diverse managerial problem configurations specific to the different stages of growth.

There exists large number of stages of growth models based on recent reviews of the literature (See Levie & Lichtenstein 2010, Muhos *et al.* 2010, Phelps et al. 2007). An analysis of the universe of such models published in the management literature as such would show neither consensus nor empirical confirmation of stages theory as many of such models/frameworks are purely conceptually based. However, there are also empirically based focused models which seem to be more consistent. Support for applicability of such models has been provided e.g. by empirical tests by for example Hanks et al. (1993) and Kazanjian & Drazin (1990). However, less attention has been paid to applicability of the models to different business contexts and to the questions of context specific aspects to "the predefined stages".

The main findings of 14 recent empirically-based stage models focusing on technology-intensive companies were synthesised into a self-evaluation framework (Muhos 2011) in order to test the central findings of the empirically based models. Until now, the framework was preliminarily tested in Thailand, Finland and Taiwan (Muhos *et al.* 2014a in press, Muhos *et al.* 2014b in press). The findings preliminarily supported the applicability of the framework in these contexts. Moreover, some context specific viewpoints were pointed out and further analysed.

In-depth analysis of the experiences of the managers of case businesses will allow an analysis of the gaps between reality and the stage models, and will highlight potential paths for further development of these models. This study aims to describe the early developmental stages of technology-intensive companies in the Californian business context.

This study bridges the gap described above by answering the following research questions: What challenges do technology-intensive companies face in their early stages, based on recent empirical literature? How do the experiences of managers in early-stage technology-intensive companies relate to the assumptions of these stage frameworks in Californian contexts? What context-specific viewpoints should be considered when using stage frameworks in the Californian context?

This is a retrospective multiple case study with a holistic research strategy. The sequential incident technique (SIT), a specific form of the critical incident technique (CIT) (Edvardsson & Roos 2001, Fisher & Oulton 1999, Flanagan 1954) is used. The following definitions figure prominently in this analysis.

We define an *early-stage technology-intensive firm* as follows. First, a technology-intensive firm is an independently owned research- and product development-intensive company, whose continuous aspiration to gain valuable, rare and inimitable technological knowledge leads to new or enhanced products and services (see Salonen 1995, Tesfaye 1997). Second, the term 'early' refers to the newness of the firm; according to Storey & Tether (1998), a new firm is not more than 25 years old. Third, the term 'stage' corresponds to a unique

configuration of variables, for example strategies, problems and priorities that growing firms will likely face (see e.g. Coad 2007, Hanks *et al.* 1991, Miller & Friesen 1984). The term 'configuration' applies to the clusters or frameworks of common variables used for the analysis of stages.

This study addresses scholars interested in the process perspective on company growth and development. The study may also function as a useful guide for those responsible for company growth and development policies, those considering investing in a defined group of companies, and the owners and managers of growing companies. In the theoretical part of this study, the current state of configuration literature is discussed. In the empirical part of the study, the nine case companies in California are described and their experiences of growth are discussed using the stage framework to identify parallel and context-specific viewpoints. Finally, this study analyses the applicability of the framework to the California companies investigated, and describes the context-specific issues.

EARLY STAGES OF GROWTH – THE SELF-EVALUATION FRAMEWORK

In this chapter, the early phases of growth in technology intensive businesses are described. The main phases of growth were earlier identified based on a literature review (See. Muhos 2011). Based on an analysis of fourteen recent and relatively consistent models, the early stages of technology intensive SMEs were defined as (1) conception and development, (2) commercialisation, (3) expansion and (4) stability/renewal.

Table 1. Early stages of technology-intensive companies: assumptions of the self-evaluation Framework

Stage	Stage description/assumption codes
1. Conception and development	The newly established firm is owner-dependent (1-A1*). The objective is product and/or technology development (1-A2) and the establishment of an early customer base (1-A3). The main activities relate to the business idea (1-A4), identification of a market (1-A5) and resource mobilisation (1-A6). The development of a working prototype is started (1-A7). The management is informal, flexible and creative (1-A8); communication is face-to-face (1-A9), and the owner makes the decisions (1-A10). The organisation functions as a product development team (1-A11). The cash flow falls into the red due to a lack of product at this point (1-A12).
2. Commercialisation	This stage begins with the early reference customers (2-A1). The objective is the creation of a business and the commercialisation of the product (2-A2). The stage is characterised by early manufacturing (2-A3), marketing (2-A4) and initial technical challenges (2-A5). The company learns to make the product and to produce it (2-A6). The management style is participative (2-A7) and coordinative (2-A8). The owner and/or a small number of partners dominate the nucleus of the administrative system (2-A9). Resource generation and survival are key issues (2-A10). The amount of negative cash flow decreases (2-A11).

Stage	Stage description/assumption codes
3. Expansion	At this stage, manufacturing and technical feasibility and market acceptance lead to high growth (3-A1) and constant change (3-A2). The main objective is to manage the company toward growth and increase market share by marketing and manufacturing the product efficiently and in high volume (3-A3). The company needs to produce, sell and distribute product at an increasing volume (3-A4) while taking care of efficiency and effectiveness through structures and processes (3-A5). New customers and new market channels require constant attention (3-A6). Personnel problems result from high growth (3-A7). The owner and/or entrepreneurial team are central, though a sense of hierarchy increases (3-A8). Budgets are moderately used for communication (3-A9). More specialised functions are considered and added (3-A10). Positive cash flow increases rapidly (3-A11).
4. Stability/renewal	The company faces a slowing growth rate (4-A1) and intense competition in the maturing product market (4-A2). An effort to launch a second generation of the product is needed, and effectiveness and efficiency issues must be addressed (4-A3). The identification of new markets is essential for company renewal (4-A4). However, cost control and productivity become main concerns (4-A5). Resulting product generation and profitability improvements help to maintain growth and reasonable market share (4-A6). The owner is usually supported by or replaced by a professional manager or a management team, and professional management systems are added (4-A7). Strategies, rules, regulations and procedures are standardised and formalised (4-A8). Employees become specialised, non-risk takers (4-A9). Specialised functions are added (4-A10). The stage is characterised by decreasing cash flow (4-A11).

*1-A1 = Stage 1, Assumption 1 (this coding will be used also in the following pages of this study)

The framework described above functions as a reference framework for this study. We use this framework to analyse and reflect upon the experiences of managers during the early stages of growth.

THE METHOD

The present research takes the form of a retrospective multiple case study. 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".

In this study, we analysed nine case companies in California, using SIT and semi-structured interviews conducted during the autumn of 2012. We examined three managerial viewpoints from each case company for triangulation purposes: one from company management, one from operations management and one from marketing management. The case study follows guidelines set by Yin (1989). In an overview of CIT methods, Gremler (2004) recognises several variants of CIT, including SIT, created to take into account the sequential character of the process being studied (see Stauss & Weinlich 1997). Case studies using SIT clarify the main stages of the process under analysis prior to the collection of data. This is advantageous

if the process has already been defined empirically. In this study, the critical incidents are reflected in the sequential framework presented in the theoretical section. The case reports are based on nine separate case studies.

The main themes of the questionnaire and the interview are presented in Appendix 1. Before the actual interview, the first part of the questionnaire was sent to the CEO for filling in the company related information (Part A1 of the interview). The Parts A2, A3, and A4 were sent to interviewees for filling in before the actual interview (Part B). The Part B, open interview, was carried out during the visit in the company, recorded, and transcribed. In the beginning of each interview, the Part A was shortly discussed to form a stable ground for the interview and to assure that the key terms were understood in similar manner.

THE RESULTS OF THE CASE STUDIES

The cases are summarised in the following table 2:

Table 2: The case companies

Case	Established	Technology	N. of employees	Sales (M$)	Assets (M$)
A	2009	Software platform development	11	1.3	2.9
B	2010	Health care technology	16	2.0	20.0
C	2009	E-commerce solutions	18	2.0	6.0
D	2003	Intelligence software	15	1.6	2.7
E	2008	Investment software	16	0.7	3.0
F	2008	Cleantech solution	65	12.0	250.0
G	1995	Logistics software	30	5.7	2.5
H	2009	Biotech	7	0.3	4.5
I	2005	E-commerce solutions	24	18.9	1.6

In the following chapters, we analyse case-by-case the critical incidents related to the early stages of growth. Aspects which are parallel and contradictory to the framework's assumptions are first presented in quantified form in order to test the applicability of the framework to each case. Then, the contradictory aspects are analysed further to point out potential context-specific aspects to be taken into account in California.

Case A: Software platform development business

The concise growth history of Case A is presented in Figure 1 below.
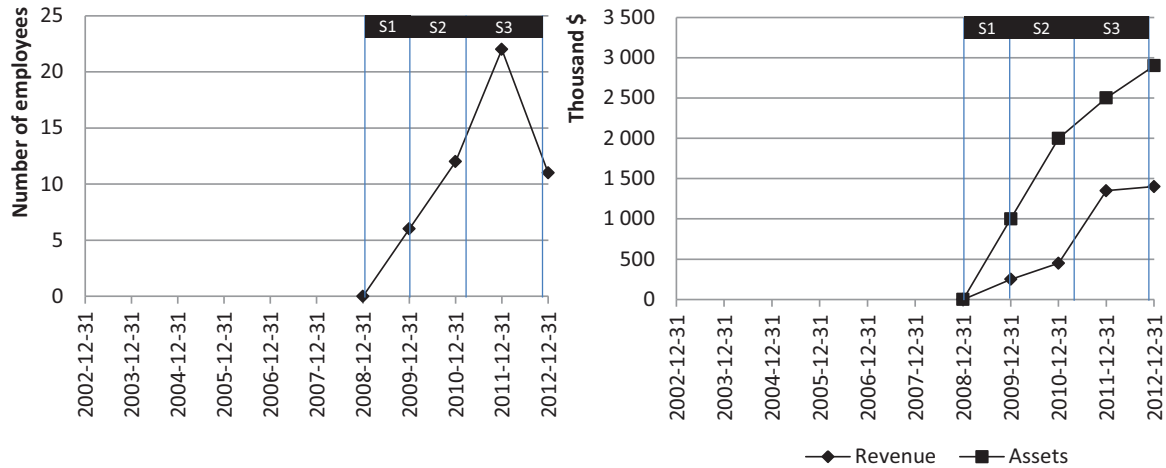
Figure 1: Growth history of Case A (S1= Stage1, S2=Stage2, S3=Stage3)

The majority of incidents recalled by the managers in this case were in line with the framework. The numbers of aspects parallel and contradictory to the assumptions of the framework found in the analysis of Case A are presented in the following table:

Table 3: Aspects related to the assumptions of the framework in three early stages of growth

Stage 1: No. of aspects			Stage 2: No. of aspects			Stage 3: No. of aspects		
A*	P**	C***	A	P	C	A	P	C
1-A1:	1	-	2-A1:	4	1	3-A1:	2	-
1-A2:	3	-	2-A2:	1	-	3-A2:	-	-
1-A3:	5	-	2-A3:	1	-	3-A3:	1	-
1-A4:	3	3	2-A4:	6	-	3-A4:	-	-
1-A5:	2	3	2-A5:	3	-	3-A5:	4	-
1-A6:	7	3	2-A6:	3	-	3-A6:	3	-
1-A7:	3	-	2-A7:	1	-	3-A7:	1	-
1-A8:	-	-	2-A8:	-	-	3-A8:	-	1
1-A9:	-	-	2-A9:	-	1	3-A9:	-	-
1-A10:	-	-	2-A10:	5	-	3-A10:	-	-
1-A11:	1	1	2-A11:	1	-	3-A11:	-	-
1-A12:	1	-						
Aspects of other stages:	1		Aspects of other stages:	6		Aspects of other stages:	-	

*A = predefined assumptions, **P = parallel aspects, ***C = contradictory aspects

The great majority of the incidents were parallel to the assumptions of the model, and thus the stage framework was found mostly applicable to Case A.

The contradictions of *Stage 1* related to assumptions 1-A4, 1-A5, and 1-A11. Contrary to 1-A4, the company was started to run "the third business idea" of the management team. The business idea did not need much adjustment or focus. The active pivoting happened before the establishment of the firm. Contrary to 1-A5, the company was established to build a new type of software platform for one customer. The size of the market was identified before the company was established. Contrary to 1-A6, there was no urgent need to mobilise people. The team was already well established before the company was founded because of the earlier pivots and projects based on earlier ideas. Finally, contradictory to 1-A11, part of the team was not ready to function as a product development team 'again'. Change resistance occurred initially because the team had already gone through multiple changes prior to the company's establishment. In addition, the company already faced fierce competition at this stage; competitors with strong resources literally stole the idea. The company was in the middle of the "fastest moving market ever created", which meant overwhelming external change.

The contradictions of *Stage 2* related to assumptions 2-A1 and 2-A9. Contrary to 2-A1, the company failed at first to identify the right reference customer, due to a reactive business model. The first customers were found "useless" in terms of reference. Contrary to 2-A9, the partners used the services of an external mentor with positive results. This mentor added value to the power structure through his applicable experience. In addition, the company already faced at this stage a partly uncontrolled growth cycle: *"the company grew too fast* [in number of employees] *with the wrong clients. And, that created organizational havoc"*. Moreover, *"the* [early] *explosion of competition created a marketplace of liars"*, where competitors offered similar services but were not capable of providing them.

The contradictions of *Stage 3* related to assumption 3-A8. Contrary to this assumption, the organisational hierarchy was actually flattened due to *"cutting the team in half"*.

Case B: Health care technology business

The concise growth history of Case B is presented in Figure 2 below.

Figure 2: Growth history of Case B (S1= Stage1, S2=Stage2, S3=Stage3)

The majority of incidents recalled by the managers in this case were in line with the framework. The numbers of aspects parallel and contradictory to the assumptions of the framework found in analysing Case B are presented in the following table:

Table 4: Aspects related to the assumptions of the framework in three early stages of growth

	Stage 1: No. of aspects			Stage 2: No. of aspects			Stage 3: No. of aspects	
A*	P**	C***	A	P	C	A	P	C
1-A1:	1	-	2-A1:	1	-	3-A1:	N/A****	N/A
1-A2:	2	-	2-A2:	5	-	3-A2:	N/A	N/A
1-A3:	3	-	2-A3:	-	-	3-A3:	N/A	N/A
1-A4:	2	-	2-A4:	4	-	3-A4:	N/A	N/A
1-A5:	4	-	2-A5:	2	-	3-A5:	N/A	N/A
1-A6:	5	-	2-A6:	-	-	3-A6:	N/A	N/A
1-A7:	2	-	2-A7:	4	-	3-A7:	N/A	N/A
1-A8:	2	1	2-A8:	1	-	3-A8:	N/A	N/A
1-A9:	-	1	2-A9:	1	1	3-A9:	N/A	N/A
1-A10:	-	-	2-A10:	7	-	3-A10:	N/A	N/A
1-A11:	1	1	2-A11:	1	-	3-A11:	N/A	N/A
1-A12:	1	-						
Aspects of other stages:	-		Aspects of other stages:	-		Aspects of other stages:	N/A	

*A = predefined assumptions, **P = parallel aspects, ***C = contradictory aspects, ****N/A= Stage 3 not reached yet

A great majority of the incidents were parallel to the assumptions of the model, and thus the stage framework was found mostly applicable to Case B.

The contradictions of *Stage 1* related to assumptions 1-A8, 1-A9 and 1-A11. Contrary to 1-A8, the original management team broke up early due to a strategic disagreement; one of the original team members did not share the vision and mission of the rest. Contrary to 1-A9, some team members unsatisfied with the equity-based reward system shut down communication links with management and started to communicate negatively within the company. Open communication was a real challenge. Finally, contradictory to 1-A11, formal organisation-building had already been tried at this stage. In addition, the company was run virtually. Only virtual office space was used in order to avoid unnecessary *'money burning'*.

The only contradictory incident in *Stage 2* related to assumption 2-A9. Contrary to this assumption, the administrative system had been broadened and strengthened already at this stage by bringing in an external adviser/mentor as CFO *"to help to expand… by sharing his knowledge."*

Case C: E-commerce solutions business

The concise growth history of Case C is presented in Figure 3 below.
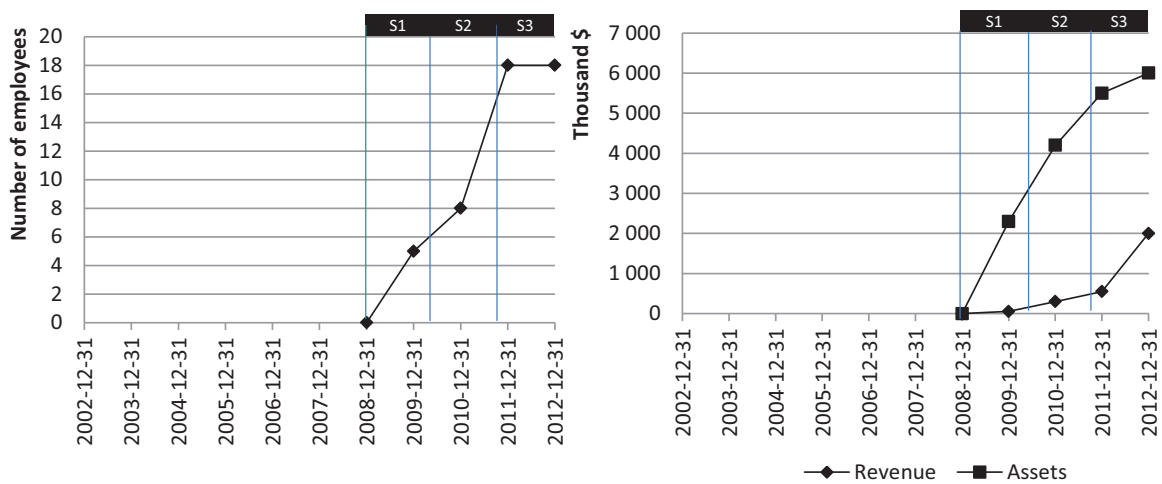
Figure 3: Growth history of Case C (S1= Stage1, S2=Stage2, S3=Stage3)

The majority of incidents recalled by the managers in this case were in line with the framework. The numbers of aspects parallel and contradictory to the assumptions of the framework found in analysing Case C are presented in the following table:

Table 5: Aspects related to the assumptions of the framework in three early stages of growth

Stage 1: No. of aspects			Stage 2: No. of aspects			Stage 3: No. of aspects		
A*	P**	C***	A	P	C	A	P	C
1-A1:	1	-	2-A1:	5	-	3-A1:	4	-
1-A2:	2	1	2-A2:	5	-	3-A2:	2	-
1-A3:	5	-	2-A3:	-	-	3-A3:	6	1
1-A4:	4	-	2-A4:	4	1	3-A4:	1	-
1-A5:	13	-	2-A5:	-	-	3-A5:	8	-
1-A6:	11	-	2-A6:	-	-	3-A6:	6	-
1-A7:	-	-	2-A7:	1	-	3-A7:	8	9
1-A8:	-	2	2-A8:	2	-	3-A8:	5	1
1-A9:	-	-	2-A9:	2	-	3-A9:	-	-
1-A10:	1	-	2-A10:	11	-	3-A10:	4	-
1-A11:	1	2	2-A11:	1	-	3-A11:	2	2
1-A12:	-	-						
Aspects of other stages:	-		Aspects of other stages:	1		Aspects of other stages:	2	

*A = predefined assumptions, **P = parallel aspects, ***C = contradictory aspects

A great majority of incidents were parallel to the assumptions of the model, and thus the stage framework was found mostly applicable to Case C.

The contradictions of *Stage 1* related to assumptions 1-A2, 1-A8 and 1-A11. Contrary to 1-A2, the company's aims from the beginning went beyond the product/service or a platform. The company aimed to build a win-win relationship with the customer. As one interviewee stated, *"We do not sell drills – we sell the holes"*. Contrary to 1-A8, the management team faced a serious communication challenge due to the overestimation of one of the founder's contributions. One founder was removed from the active business. Contrary to 1-A11, the company hired corporate people who were not in sync with the mind frame of the start-up. This situation disturbed the structure of the product development team temporarily. These hires were expensive and unsuccessful.

The contradictions of *Stage 2* related to assumption 2-A4. Contrary to this assumption, in terms of marketing, the company *"stayed below the radar"* until it won the Red Herring Award. Also, already at this stage, the company focused on effectiveness through its organisational system: *"organizational systems can create frustration in an organization. ...and you know that you don't have the organizational platform to move it forward and you just can't get it off the ground, ...it's demoralising. We've had that happen a couple times and I expect it to happen in the future, it's just the nature of development."*

The contradictions of *Stage 3* related to assumptions 3-A3, 3-A7, 3-A8 and 3-A11. Contrary to 3-A3, the company is carving out a platform niche: *"So we're not selling a product, we're selling a platform that people can use to achieve the why. ...it's not our store, it's the* [customers] *store."* Contrary to 3-A7, growth was also extremely positive (in many ways) for the employees in terms of ownership, options, excitement, awards, career development and commitment. Contrary to 3-A8, everyone participates in different areas of the business. Contrary to 3-A11, one of the owners states: *"we're stage three with not a lot of revenue performance* [compared to some other businesses]*"*. In addition, the company still faces some challenges of resource generation relative to earlier stages: *"...we can get up and running and in a reasonable amount of time and if we just had more money, we could do it, times ten, maybe times twenty, just with the amount of dollars that would be almost insignificant to a venture firm in Silicon Valley or to a bank that could, you know..."*

Case D: Intelligence software business

The concise growth history of Case D is presented in Figure 4 below.
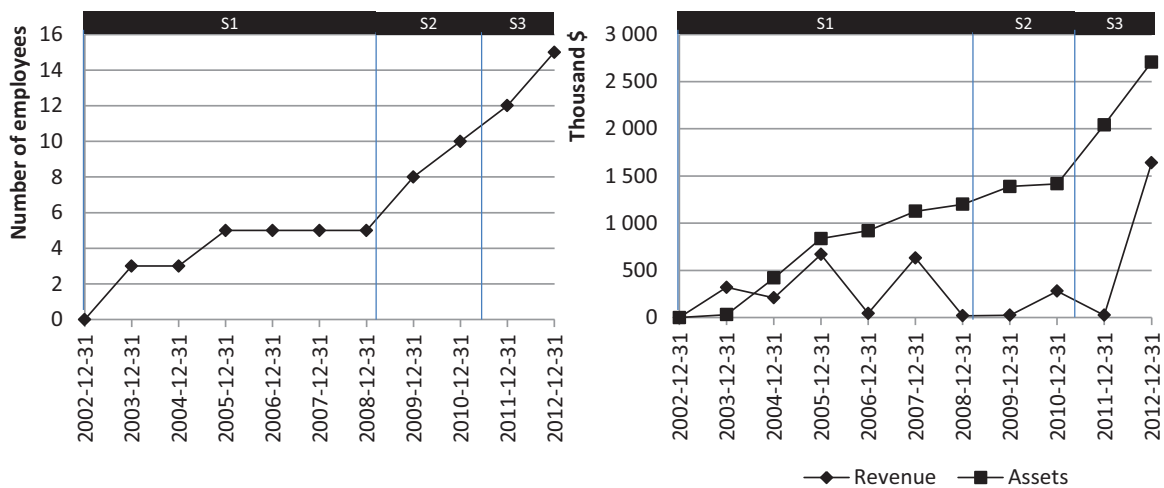
Figure 4: Growth history of Case D (S1= Stage1, S2=Stage2, S3=Stage3)

The majority of incidents recalled by the managers of the Case were in line with the framework. The numbers of aspects parallel and contradictory to the assumptions of the framework found in the analysis of Case D are presented in the following table:

Table 6: Aspects related to the assumptions of the framework in three early stages of growth

Stage 1: No. of aspects			Stage 2: No. of aspects			Stage 3: No. of aspects		
A*	P**	C***	A	P	C	A	P	C
1-A1:	2	-	2-A1:	1	2	3-A1:	2	6
1-A2:	4	-	2-A2:	8	-	3-A2:	5	-
1-A3:	4	1	2-A3:	-	-	3-A3:	5	2
1-A4:	-	-	2-A4:	5	-	3-A4:	2	-
1-A5:	3	2	2-A5:	3	-	3-A5:	2	-
1-A6:	7	-	2-A6:	2	-	3-A6:	7	-
1-A7:	5	-	2-A7:	2	-	3-A7:	10	7
1-A8:	1	-	2-A8:	-	-	3-A8:	3	3
1-A9:	1	-	2-A9:	-	1	3-A9:	-	-
1-A10:	1	-	2-A10:	11	-	3-A10:	1	-
1-A11:	-	3	2-A11:	-	-	3-A11:	-	8
1-A12:	1	-						
Aspects of other stages:	-		Aspects of other stages:	-		Aspects of other stages:	12	

*A = predefined assumptions, **P = parallel aspects, ***C = contradictory aspects

A great majority of the incidents were parallel to the assumptions of the model, and thus the stage framework was found mostly applicable to Case D.

The contradictions of *Stage 1* related to assumptions 1-A3, 1-A5 and 1-A11. Contrary to 1-A3, in a science-based company, development of the core technology (a fundamentally new type of algorithm) took up all the attention in the beginning. Contrary to 1-A5, the technology was not originally developed for specific customer applications. The focus was on developing a fundamentally game-changing technology, and market identification was seen as a secondary objective. Contrary to 1-A11, the organisation functioned first as a research team of scientists with the objective of testing whether it had a value proposition in terms of its core technology. Taking pure concepts, translating them into software and making sure that the software embodies the pure theoretical concepts properly was a primary challenge. Keeping the team focused over a long period was also a challenge. Also, in the beginning, the technology was seen as marginal by the public. The core technology of a company is a theoretically-based value proposition, and implementation was not the focus. In the beginning, the company was comparable to an academic research group with distant business objectives, with a long way to go to reach practical solutions.

The contradictions of *Stage 2* related to assumptions 2-A1 and 2-A9. Contrary to 2-A1, an early reference customer became a negative reference: *"...that big contract when that customer failed, was a big negative. ... And so, we made, we put out press releases, we had some videos and we referred, you know, their logo ends up embedded in all this marketing*

material somewhere, and then when it crashes, you've got all that out there…" Contrary to 2-A9, there was a significant change in the nucleus of the administrative system: *"...company got bought, folded into this company; it was basically a merger of the two."*

The contradictions of *Stage 3* related to assumptions 3-A1, 3-A3, 3-A7, 3-A8 and 3-A11. Contrary to 3-A1, "*growth was very mediocre. We had a few sales; really barely enough to really justify the company. ...the technology needed to be migrated into a different platform. ...We're going to transition both technically and the way we're going to market."* Contrary to 3-A3, at this point the growth of the company was heavily dependent on external funding: *"...you have 170 investors, then, institutional capital now when you're ready to really begin expanding, if you need to go find (five millions and) ten millions, you don't do that with individuals. Unless you go to the public markets and we're too early for that. ...So that makes it harder to raise that next round of money, because you have to find the right investment fund and, when it's done it looks like it'll be kind of a family office sort of, those are, slightly different institutional investors."* Contrary to 3-A7, this stage was very positive (in many terms) for the employees in terms of excitement, motivation, awards, maturing staff, autonomy of work and sense of purpose (development of a fundamentally paradigm shifting technology). Contrary to 3-A8, the company hierarchy is flat: "*...a real entrepreneurial kind of structure that we have, it's collaborative, it's extremely flat, a lot of that's based on trust and a real common vision and strategy, so we operate seemingly independent from each other, but we operate in much the same way."* Contrary to 3-A11, positive cash flow is still on the way: "*…you have to do them up against the backdrop of the nasty little thing called cash and resources, right. ...So, the stuff that gets in the headlines are the Silicon Valley guys that raise 5 million, 10 million, 20 million, and then they hire all the superstar guys and, you know, life's wonderful. But for 99.9 percent of the world out there, you don't have those resources. ... What we will start doing before the end of this year is actually driving cash flow and revenue off of an application that later on we'll probably just sell to somebody in that space, because our model's really to get licensing revenue from that, right. So, we've created, what we've done is sort of created a customer.* In addition, some issues are still reminiscent of earlier stages, like resource generation challenges (money and people), technical challenges and a survival game.

Case E: Investment software business

The concise growth history of Case E is presented in Figure 5 below.
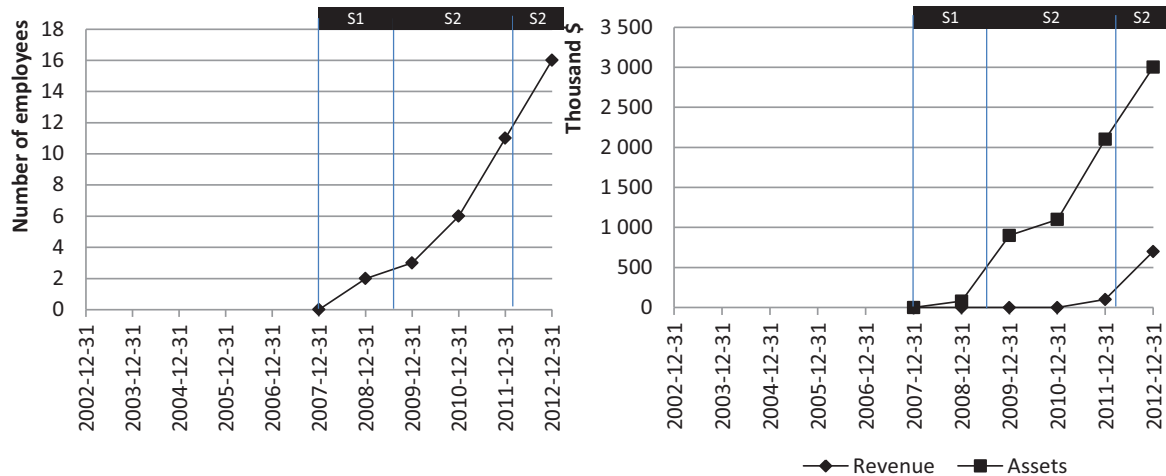
Figure 5: Growth history of Case E (S1= Stage1, S2=Stage2, S3=Stage3)

The majority of the incidents recalled by managers in this case were in line with the framework. The numbers of aspects parallel and contradictory to the assumptions of the framework found in the analysis of Case E are presented in the following table:

Table 7: Aspects related to the assumptions of the framework in three early stages of growth

Stage 1: No. of aspects			Stage 2: No. of aspects			Stage 3: No. of aspects		
A*	P**	C***	A	P	C	A	P	C
1-A1:	1	-	2-A1:	1	-	3-A1:	3	-
1-A2:	1	-	2-A2:	1	-	3-A2:	2	-
1-A3:	1	-	2-A3:	-	-	3-A3:	2	-
1-A4:	1	-	2-A4:	2	-	3-A4:	-	-
1-A5:	4	-	2-A5:	1	-	3-A5:	-	-
1-A6:	1	-	2-A6:	1	-	3-A6:	-	-
1-A7:	1	-	2-A7:	1	-	3-A7:	1	1
1-A8:	3	-	2-A8:	-	-	3-A8:	2	-
1-A9:	2	-	2-A9:	1	-	3-A9:	-	-
1-A10:	2	-	2-A10:	7	-	3-A10:	4	-
1-A11:	1	-	2-A11:	-	-	3-A11:	-	-
1-A12:	1	-						
Aspects of other stages:	-		Aspects of other stages:	-		Aspects of other stages:	-	

*A = predefined assumptions, **P = parallel aspects, ***C = contradictory aspects

A great majority (with only one exception) of the incidents were parallel to the assumptions of the model, and thus the stage framework was found applicable to Case E.

In *Stages 1 and 2* only aspects parallel to the assumptions were found.

The only contradiction in *Stage 3* related to assumption 3-A7. This stage was very positive (in many terms) for the employees, especially in terms of motivation and trust in the business model.

Case F: Recycling solution business

The concise growth history of Case F is presented in Figure 6 below.
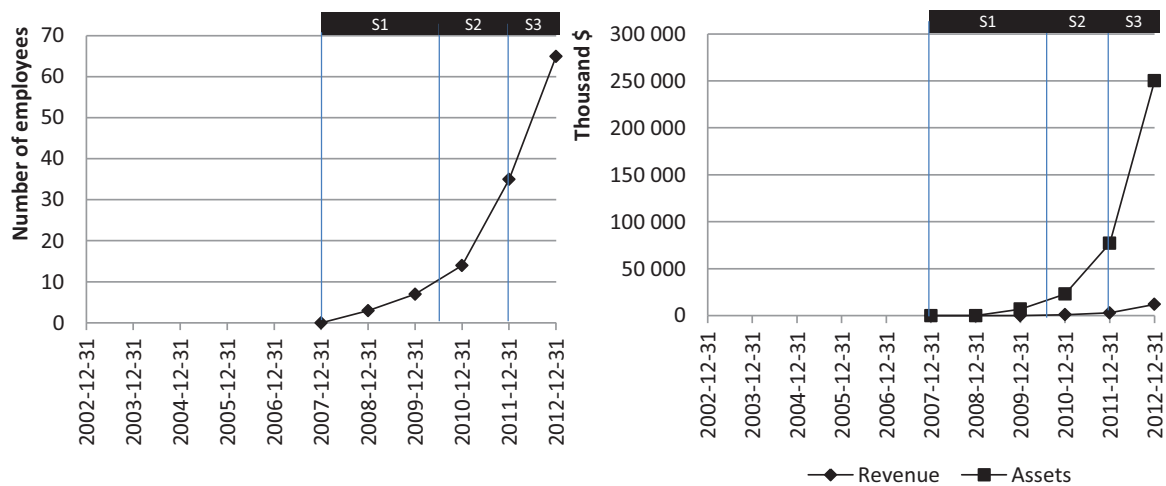
Figure 6: Growth history of Case F (S1= Stage1, S2=Stage2, S3=Stage3)

The majority of incidents recalled by the managers of the Case were in line with the framework. The numbers of aspects parallel and contradictory to the assumptions of the framework found in the analysis of Case F are presented in the following table:

Table 8: Aspects related to the assumptions of the framework in three early stages of growth

Stage 1: No. of aspects			Stage 2: No. of aspects			Stage 3: No. of aspects		
A*	P**	C***	A	P	C	A	P	C
1-A1:	2	-	2-A1:	2	-	3-A1:	5	-
1-A2:	4	-	2-A2:	2	-	3-A2:	6	-
1-A3:	5	-	2-A3:	1	-	3-A3:	1	-
1-A4:	10	-	2-A4:	11	-	3-A4:	2	1
1-A5:	7	-	2-A5:	5	-	3-A5:	2	-
1-A6:	16	-	2-A6:	5	-	3-A6:	-	-

Stage 1:			Stage 2:			Stage 3:		
No. of aspects			No. of aspects			No. of aspects		
A*	P**	C***	A	P	C	A	P	C
1-A7:	6	-	2-A7:	2	-	3-A7:	5	4
1-A8:	1	-	2-A8:	1	-	3-A8:	6	-
1-A9:	2	-	2-A9:	1	-	3-A9:	1	-
1-A10:	2	-	2-A10:	9	-	3-A10:	4	-
1-A11:	1	-	2-A11:	2	-	3-A11:	4	-
1-A12:	-	-						
Aspects of other stages:	2		Aspects of other stages:	3		Aspects of other stages:	2	

*A = predefined assumptions, **P = parallel aspects, ***C = contradictory aspects

A great majority of the incidents were parallel to the assumptions of the model, and thus the stage framework was found mostly applicable to Case F.

Stage 1 showed no contradictions to the assumptions of the framework. However, two incidents related to the assumptions of other stages were pointed out. This company started to pivot very early with customers ready to pay. This approach validated the Minimum Viable Product (MVP) and supported growth in the later stages: *"So then we built out another 12 to 15* [products]*, over the next three months and we started installing those… And we put those in the* [marketplace]*, and they immediately just took off. People were using them* [daily]*. It was, it surpassed our expectations of how quickly they would ramp, how many people would use them. …it was time to raise some money."*

Stage 2 showed no contradictions to the assumptions of the framework. However, three incidents were pointed out which related to the assumptions of other stages. This company started to scale very early due to successful early pivots and proven market acceptance at Stage 1: *"…the amount that we spent out there fixing the* [product] *or, retrofitting broken stuff is very negligible, now that you look at the fact that we were able to grow so quickly. … We've always been, ready to handle the increasing capacity or, we have the software that we need ready for, supporting* [products] *that are across the country. …We're just prepared."*

The contradictions at *Stage 3* related to assumptions 3-A4 and 3-A7. Contrary to 3-A4, the company outsourced much of its full-scale manufacturing to a partner company: *"…we've had a great relationship with our manufacturer that also helps to do some of the design. And they had executed better than any contract manufacturer I've ever worked with. In fact they invested in the company, the management we're all great friends, they do a great job."* Contrary to 3-A7, this stage was extremely positive for the employees: *"…and they weren't just mediocre people, they're world-class, the executives and that decision-making and the talent in that group is what's really gotten us here. So it's a great team and it was put together early and it survived. Not only survived but it's thrived and, I wouldn't replace any of them."* In addition, two incidents related to the assumptions of other stages were pointed

out. First, the owner had already considered at this stage the support of a professional manager and management systems. Second, through agile development, the company is already running the third generation of its core technology.

Case G: Diversified technology business

The concise growth history of Case G is presented in Figure 7 below.
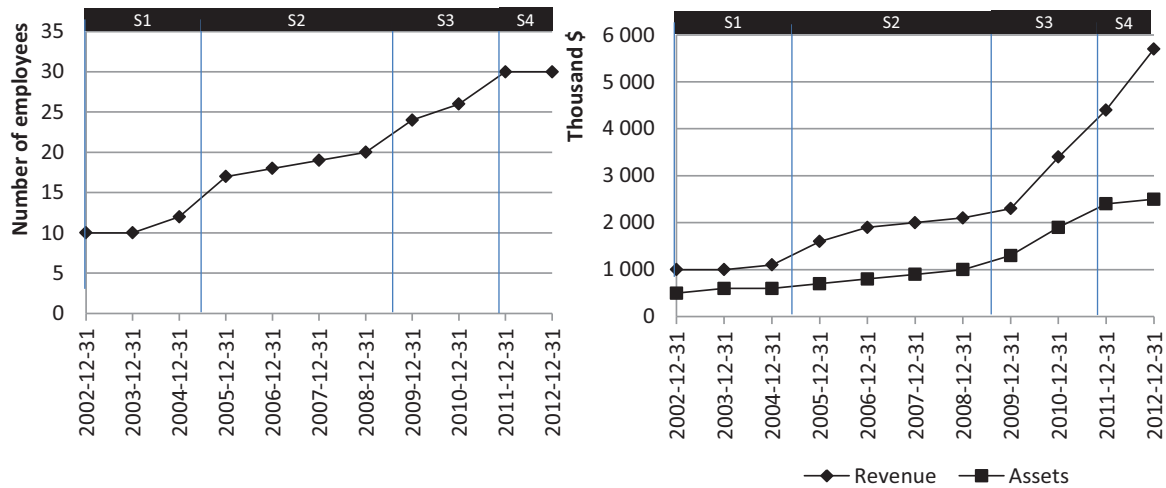
Figure 7: Growth history of Case G (S1= Stage1, S2=Stage2, S3=Stage3, S4=Stage 4)

The majority of incidents recalled by managers in this case were in line with the framework. The numbers of aspects parallel and contradictory to the assumptions of the framework found in the analysis of Case G are presented in the following table:

Table 9: Aspects related to the assumptions of the framework in three early stages of growth

Stage 1: No. of aspects			Stage 2: No. of aspects			Stage 3: No. of aspects		
A*	P**	C***	A	P	C	A	P	C
1-A1:	3	-	2-A1:	3	-	3-A1:	-	-
1-A2:	3	6	2-A2:	5	-	3-A2:	7	-
1-A3:	4	-	2-A3:	-	-	3-A3:	2	-
1-A4:	1	1	2-A4:	3	-	3-A4:	-	-
1-A5:	1	1	2-A5:	-	-	3-A5:	5	-
1-A6:	5	-	2-A6:	1	1	3-A6:	5	-
1-A7:	1	4	2-A7:	5	-	3-A7:	5	1
1-A8:	1	-	2-A8:	-	-	3-A8:	6	-
1-A9:	-	1	2-A9:	1	-	3-A9:	1	-
1-A10:	-	-	2-A10:	7	-	3-A10:	4	-
1-A11:	4	-	2-A11:	-	1	3-A11:	5	-
1-A12:	-	3						
Aspects of other stages:	-		Aspects of other stages:	1		Aspects of other stages:	2	

*A = predefined assumptions, **P = parallel aspects, ***C = contradictory aspects

A great majority of the incidents were parallel to the assumptions of the model, and thus the stage framework was found mostly applicable to Case G.

The contradictions of *Stage 1* related to assumptions 1-A2, 1-A4, 1-A5, 1-A7, 1-A9 and 1-A12. Contrary to 1-A2, having attempted to launch some of its own products into *"the first space"*, the company learned *"pretty quickly we weren't very good at it… and then we sort of exited from that because we weren't successful."* Thus, the company focused temporarily for a couple of years on its software project business. Contrary to 1-A4, the main focus was on development of products for customers. Contrary to 1-A5, the company had not yet managed to identify its own-product-market. Contrary to 1-A7, *"from 1995 to 2005 we were largely doing software development for local businesses and federal government customers."* Contrary to 1-A9, instead of smooth face-to-face communication, the company had some *"miscommunication in the beginning"*. Contrary to 1-A12, the company did not suffer from increasingly negative cash flow due to its back-up business model: *"And it was a very modest growth. We lived, OK, comfortable living but never really, aspiring to a specific, growth plan. I started maturing, my partner was older and he was retiring. …So if you look at kind of the data where, we were very anaemic, very very slow growth or no growth from 1995 to roughly 2005. 2005 to 2007 we had a little bit of growth because of the merger."*

The contradictions of *Stage 2* related to assumptions 2-A6 and 2-A11. Contrary to 2-A6, the company had its product ready, but it was "on hold" for a while: *"…we've, sort of from the beginning we had a product already. …with* [the core technology] *and that kind of stuff, there*

*really wasn't that much of a learning curve with that. That was kinda, this is what we do and
we just send it out.*" Contrary to 2-A11, the company's cash flow was positive because of
survival project business: "*...three or four years, with the economy being as bad as it is, and
that we were still able to grow and leverage and bring cash in and have a positive income,
when a lot of companies were laying off people and that kind of thing.*" In addition, the
company was already able to expand gradually at this stage.

Since successfully launching the core product, the only contradiction at *Stage 3* related to
assumption 3-A7. Contrary to this assumption, this stage was very positive (in many terms)
for the employees, in terms of increased excitement and passion, and positive team building.
In addition, the company encountered some incidents at this stage that related to the
assumptions of the other stages. Already at this stage, the competition had increased as some
companies brought similar products to the market with a different business model.

Case H: Biotech business

The concise growth history of Case H is presented in Figure 8 below.
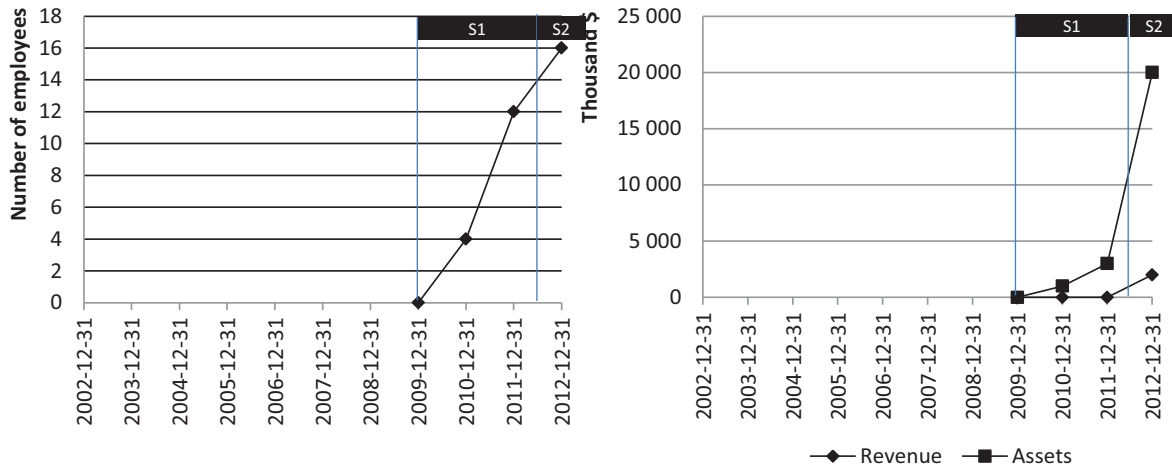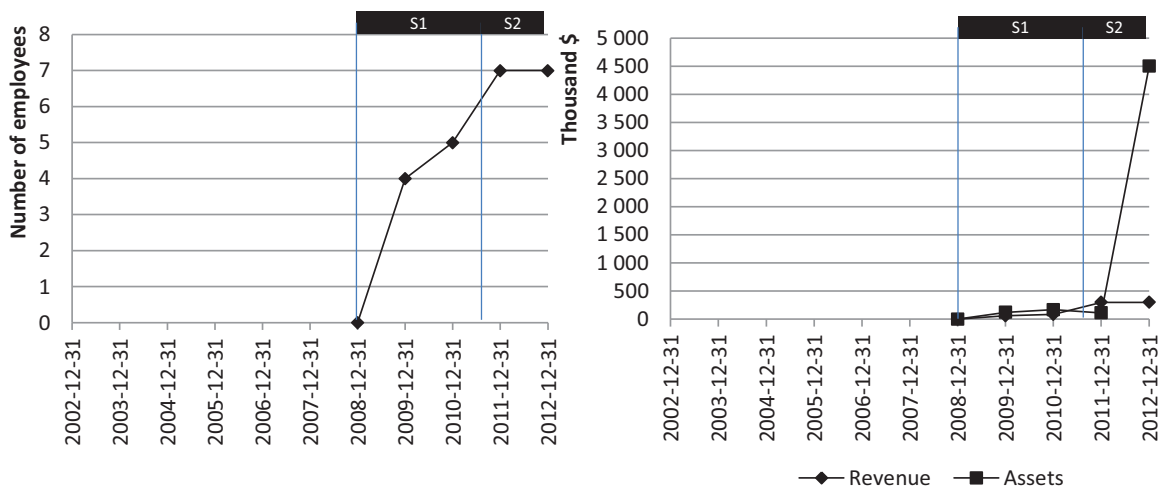

Figure 8: Growth history of Case H (S1= Stage1, S2=Stage2, S3=Stage3, S4=Stage 4)

The majority of the incidents recalled by managers in this case were in line with the
framework. The numbers of aspects parallel and contradictory to the assumptions of the
framework found in the analysis of Case H are presented in the following table:

Table 10: Aspects related to the assumptions of the framework in three early stages of growth

Stage 1: No. of aspects			Stage 2: No. of aspects			Stage 3: No. of aspects		
A	P	C	A	P	C	A	P	C
1-A1:	3	-	2-A1:	2	-	3-A1:	N/A****	N/A
1-A2:	4	-	2-A2:	2	3	3-A2:	N/A	N/A
1-A3:	-	3	2-A3:	-	-	3-A3:	N/A	N/A
1-A4:	1	-	2-A4:	2	-	3-A4:	N/A	N/A
1-A5:	1	-	2-A5:	3	-	3-A5:	N/A	N/A
1-A6:	7	-	2-A6:	3	1	3-A6:	N/A	N/A
1-A7:	1	-	2-A7:	2	-	3-A7:	N/A	N/A
1-A8:	-	-	2-A8:	-	-	3-A8:	N/A	N/A
1-A9:	-	-	2-A9:	2	-	3-A9:	N/A	N/A
1-A10:	-	-	2-A10:	7	-	3-A10:	N/A	N/A
1-A11:	1	-	2-A11:	1	-	3-A11:	N/A	N/A
1-A12:	-	-						
Aspects of other stages:	-		Aspects of other stages:	-		Aspects of other stages:	N/A	

*A = predefined assumptions, **P = parallel aspects, ***C = contradictory aspects, ****N/A=company has not reached this stage yet

A great majority of the incidents were parallel to the assumptions of the model, and thus the stage framework was found mostly applicable to Case H.

The contradictions of *Stage 1* related to assumption 1-A3. Contrary to 1-A3, the early customer base did not develop as planned: *"…the customers are just not there. We just misread the size of the market, thought more people would adopt* [the core technology]. *We missed that, completely."*

The contradictions of *Stage 2* related to assumptions 2-A2 and 2-A6. Contrary to 2-A2, *"the idea was to build a company where the assets* [Knowledge, IPR] *would grow significantly for an exit strategy."* Contrary to 2-A6, the company has prepared its technology and laboratory practises ready for exit through acquisition: *"So, our products don't have to be approved by the government, because they're used in research. But it's good for us to be practising good laboratory practices in our manufacturing. …And that's going to be a positive thing when people come in eventually and look at us for acquisition."*

Case I: E-commerce solutions company

The concise growth history of Case I is presented in Figure 9 below.
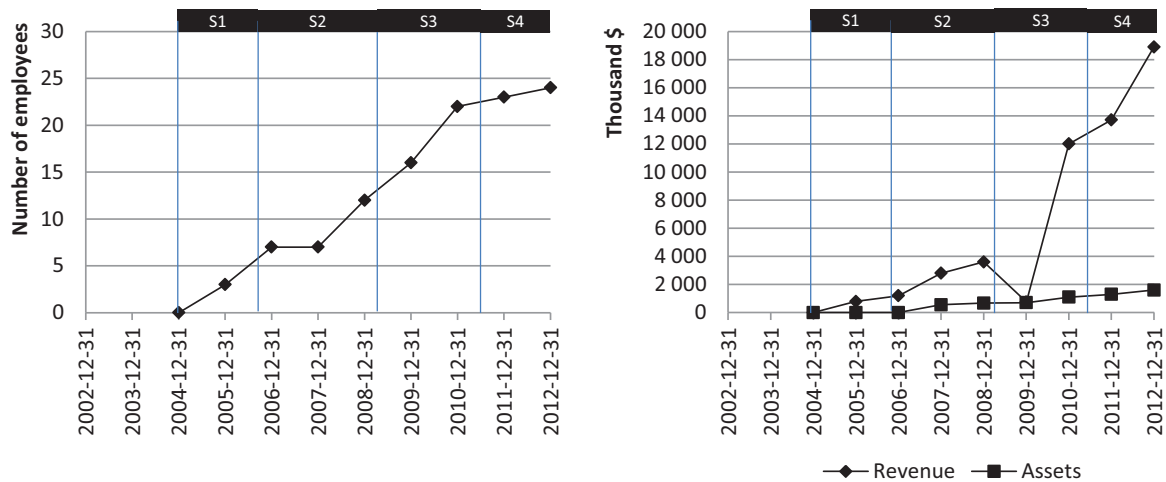
Figure 9: Growth history of Case I (S1= Stage1, S2=Stage2)

The majority of the incidents recalled by managers in this case were in line with the framework. The numbers of aspects parallel and contradictory to the assumptions of the framework found in the analysis of Case I are presented in the following table:

Table 11: Aspects related to the assumptions of the framework in three early stages of growth

Stage 1: No. of aspects			Stage 2: No. of aspects			Stage 3: No. of aspects		
A*	P**	C***	A	P	C	A	P	C
1-A1:	6	-	2-A1:	2	-	3-A1:	4	-
1-A2:	3	1	2-A2:	-	-	3-A2:	1	-
1-A3:	1	-	2-A3:	-	-	3-A3:	-	-
1-A4:	2	-	2-A4:	-	2	3-A4:	1	-
1-A5:	-	-	2-A5:	-	-	3-A5:	1	-
1-A6:	4	-	2-A6:	1	-	3-A6:	2	-
1-A7:	-	4	2-A7:	-	-	3-A7:	-	1
1-A8:	1	-	2-A8:	-	-	3-A8:	1	-
1-A9:	-	-	2-A9:	1	-	3-A9:	-	-
1-A10:	1	-	2-A10:	9	-	3-A10:	2	-
1-A11:	1	-	2-A11:	-	-	3-A11:	4	-
1-A12:	-	2						
Aspects of other stages:	-		Aspects of other stages:	2		Aspects of other stages:	2	

*A = predefined assumptions, **P = parallel aspects, ***C = contradictory aspects

A great majority of the incidents were parallel to the assumptions of the model, and thus the stage framework was found mostly applicable to Case I.

The contradictions of *Stage 1* related to assumptions 1-A2, 1-A7, and 1-A12. Contrary to 1-A2, the management team already had the basic core of the product from an earlier business venture. Contrary to 1-A7, the company did not have to focus on development of a working prototype as *"the product was first developed in the old company. So the product was already technically coded before we even launched the company. ...we had a working product. So, stage one; it was more getting the product noticed."* Contrary to 1-A12, the negative cash flow was not due to lack of product: *"...the first three years was basically just throwing money out. I mean, just continuously. ...we were actually doing well on sales, so, but we weren't doing well enough that it was... It wasn't really self-sustaining at that point."*

The contradictions of *Stage 2* related to assumption 2-A4. Contrary to this assumption, *"...we never really did any kind of marketing. It was all, it was either word of mouth, or search engine optimization, so we didn't really have any marketing goals that we met, we were really doing until* [later stages]. *...we were growing so fast anyway, we didn't really have to think about marketing."* In addition, the company was already growing: *"...when we hit a thousand customers, I think that was a huge deal. Because it was just, it just seemed like wow, a thousand using our [product]. It just seemed like such a big number at the time. And, I remember sitting in a meeting in New York, (in our) office(s) there, and saying we just hit a thousand activations. ...And then we thought OK, if we can do 1000, I bet you we can do 10 000, within a couple more years."*

The contradictions of *Stage 3* related to assumption 3-A7. Contrary to 3-A7, this stage was very positive (in many terms) for the employees in terms of shared vision, commitment and trust. In addition, the company had already reached a very strong market position at this stage: *"And then, after about three years we figured out, not only we were the best product, we were the only product, which was really nice. ...we pretty much just, were just expanding, incredibly expanding. It was, basically every month we were doubling our customer base, (it was) just like boom, boom. And then about two thousand... then before you know it the company's now in the position to buy other companies instead of being bought."*

CROSS-CASE ANALYSIS

Altogether, 793 critical incidents were found in the cases. Of these critical incidents, 683 were parallel to the assumptions of the framework, and 110 were contradictory to the assumptions of the framework.

The number of incidents related to the assumptions of the framework for each case company is presented in Table 12:

Table 12: The number of incidents related to the assumptions of the framework for each case

Cases	Stage 1: No. of aspects		Stage 2: No. of aspects		Stage 3: No. of aspects	
	P*	C**	P	C	P	C
Case A	26	10	25	2	11	1
Case B	23	3	26	1	N/A***	N/A
Case C	38	5	31	-	46	13
Case D	29	6	32	3	37	26
Case E	19	-	15	-	14	1
Case F	56	-	41	-	36	5
Case G	23	16	25	2	40	1
Case H	18	3	24	4	N/A	N/A
Case I	19	7	13	-	16	1
Total	251	50	232	12	200	48

*P = parallel aspects, **C = Contrary aspects, ***N/A=this stage not reached yet

The total number of incidents related to the assumptions of the various stages is presented in Table 13:

Table 13: The total number of incidents related to each assumption of the framework

A*	Stage 1: No. of aspects		A	Stage 2: No. of aspects		A	Stage 3: No. of aspects	
	P**	C***		P	C		P	C
1-A1:	20	-	2-A1:	21	3	3-A1:	20	6
1-A2:	26	8	2-A2:	29	3	3-A2:	23	-
1-A3:	28	4	2-A3:	2	-	3-A3:	17	3
1-A4:	24	4	2-A4:	37	3	3-A4:	6	1
1-A5:	35	6	2-A5:	17	-	3-A5:	22	-
1-A6:	63	3	2-A6:	16	2	3-A6:	23	-
1-A7:	19	8	2-A7:	18	-	3-A7:	30	23
1-A8:	9	3	2-A8:	4	-	3-A8:	23	5
1-A9:	5	2	2-A9:	9	3	3-A9:	2	-
1-A10:	7	-	2-A10:	73	-	3-A10:	19	-
1-A11:	11	7	2-A11:	6	1	3-A11:	15	10
1-A12:	4	5						
Aspects of other stages:	3		Aspects of other stages:	13		Aspects of other stages:	20	

*A = predefined assumptions, **P = parallel aspects, ***C = contradictory aspects

As shown above, the majority of the incidents were parallel to the framework. In fact, every assumption of the framework found support from at least one of the cases and many from every case. The nine cases mostly supported the assumptions of the framework. The

empirically-based stage framework seems to form an effective tool for reflecting on and predicting challenges faced during the early development of a company.

DISCUSSION

The applicability of Stages 1-3 of the four stage framework was explored in this study; moreover, an analysis of context-specific viewpoints was provided. It is necessary to recognise these viewpoints when using this framework in California.

As an answer to *the first research question*, the meta-analytical synthesis, a four-stage self-evaluation framework for early-stage technology-intensive companies, was devised. The stages include conception and development, commercialisation, expansion and stability/renewal. Table 1 details these stages. This study used the synthesis as a set of assumptions to test by means of nine case studies.

Using the nine case studies, the authors answered *the second research question* using SIT. We analysed nine cases from California to test how the experiences of the managers related to the assumptions of the framework. The applicability of the framework was preliminarily tested in the context of California by analysing the number and content of parallel aspects in relation to the assumptions of the framework. The results are provided in Table 14 below.

Table 14: The three stages of the framework and the share of the case companies with parallel experiences

Stage	Stage description/assumption codes
1. Conception and development	**The newly established firm is owner-dependent (1-A1). The objective is product and/or technology development (1-A2)** *and the establishment of an early customer base (1-A3). The main activities relate to the business idea (1-A4), identification of a market (1-A5)* **and resource mobilisation (1-A6).** *The development of a working prototype is started (1-A7). The management is informal, flexible and creative (1-A8);* communication is face-to-face (1-A9), *and the owner makes the decisions (1-A10). The organisation functions as a product development team (1-A11).* The cash flow falls into the red due to a lack of product at this point (1-A12).
2. Commercialisation	**This stage begins with the early reference customers (2-A1).** *The objective is the creation of a business and the commercialisation of the product (2-A2).* The stage is characterised by early manufacturing (2-A3), *marketing (2-A4) and initial technical challenges (2-A5). The company learns to make the product and to produce it (2-A6). The management style is participative (2-A7)* and coordinative (2-A8). *The owner and/or a small number of partners dominate the nucleus of the administrative system (2-A9).* **Resource generation and survival are key issues (2-A10).** *The amount of negative cash flow decreases (2-A11).*

Stage	Stage description/assumption codes
3. Expansion	*At this stage, manufacturing and technical feasibility and market acceptance lead to high growth (3-A1) and constant change (3-A2). The main objective is to manage the company toward growth and increase market share by marketing and manufacturing the product efficiently and in high volume (3-A3).* The company needs to produce, sell and distribute product at an increasing volume (3-A4) *while taking care of efficiency and effectiveness through structures and processes (3-A5). New customers and new market channels require constant attention (3-A6). Personnel problems result from high growth (3-A7). The owner and/or entrepreneurial team are central, though a sense of hierarchy increases (3-A8).* Budgets are moderately used for communication (3-A9). *More specialised functions are considered and added (3-A10).* Positive cash flow increases rapidly (3-A11).

bold = the assumption is supported by every case; ***bold italic*** = the assumption is supported by the majority of the cases; normal = the assumption is supported by a minority of the cases; *italic* = the assumption is not supported.

The results provide preliminary support for the applicability of the framework, as all its assumptions are supported by one or more cases.

The study's *third research question* clarifies the contradictory (fresh), context-specific viewpoints of the stage framework from a Californian perspective. The context-specific viewpoints are presented in the cases provided in this study. The context-specific viewpoints are described in detail in the results of the case studies.

To conclude, this study formulated and preliminarily tested the first three phases of a four-stage framework describing the early stages of technology-intensive companies. The nine cases evaluated mostly supported the assumptions of the framework. The empirically-based stage framework seems to be an effective tool for reflecting on and predicting the challenges faced during the early development of a company. Moreover, this study revealed a number of context-specific viewpoints contradictory to the framework: companies in different contexts face culture- and context-specific issues in their early growth. Growth is a multidimensional phenomenon, and every early technology-intensive company is to some extent unique.

The case-study strategy using SIT proved effective for the open-ended analysis of early growth, taking the sequential character of the process into account. The construct validity of the study is based on a sound research plan, multiple sources of evidence, synergy between quantitative and qualitative data and an established chain of evidence. Analytic generalisation (generalisation to a theory) is possible in the case of building context-specific frameworks applicable to the Californian context. The research focus of this study is partly limited to the context studied. The findings of the study cannot be directly generalised to other countries or business contexts, and they depend on the time of data collection. Reproducing the same case

study in the same environment later would change some of the findings. However, case-study protocol was followed and a database established, allowing further testing of the findings.

This study is one step in an attempt to clarify context-specific perspectives on the early stages of technology-intensive businesses in different business contexts. Up until now four contexts – Finland, Thailand, Taiwan and USA (California) – have been analysed. In future studies, more contexts could be examined, and additional case studies in the context of California could provide more detail. These findings could also be further empirically tested (for examples of such tests, see Hanks and Chandler, 1994; Kazanjian and Drazin, 1989). Opening up other regional or industry-specific business contexts to a similar methodology would offer a broad range of opportunities for framework testing and for pointing out context-specific issues. It would be interesting to compare the results of similar analyses in other countries in future work. Moreover, the role of intermediaries in this challenging area requires closer examination. In order to support the growth of technology intensive businesses and to remove structural and context-specific growth barriers; new knowledge and actions are needed.

ACKOWLEDGEMENTS

REFERENCES

1. Churchill NC & Lewis VL (1983) *The five stages of small business growth.* Harvard business review 61(3): 30-50.
2. Coad A (2007) *Firm Growth: A Survey.* Max Planck Institute Papers on Economics & Evolution : 1-72.
3. Coase RH (1937) *The Nature of the Firm.* Economica 4(16): 386-405.
4. Davidsson P & Wiklund J (2006) 3. Conceptual and empirical challenges in the study of firm growth. Entrepreneurship And the Growth of Firms .
5. Edvardsson B & Roos I (2001) *Critical incident techniques.* International Journal of Service Industry Management 12(3): 251-268.
6. Fisher S & Oulton T (1999) *The critical incident technique in library and information management research.* Educ Inf 17(2): 113-125.
7. Flanagan JC (1954) *The critical incident technique.* Psychol Bull 51(4): 327-358.
8. Gibrat R (1931) Les inégalités économiques. Paris, Recueil Sirey.

9. Greiner L (1972) *Evolution and revolution as organisations grow.* Harward Business Review 50(4): 37-46.

10. Gremler D (2004) *The Critical Incident Technique in Service Research.* Journal of Service Research 7(1): 65-89.

11. Hanks, SH and Chandler G (1994) *Patterns of functional specialization in emerging high tech firms*, J. Small Bus. Manage., 32 (2): 23–37.

12. Hanks SH, Watson CJ & Jansen E (1991) *Toward a configurational taxonomy of the organization life cycle.* In: Hills G & LaForge R (eds) Research at the Marketing/Entrepreneurship Interface, Chicago, University of Illinois Press.

13. Hanks SH, Watson CJ, Jansen E & Chandler GN (1993) *Tightening the Life-Cycle Construct: A Taxonomic Study of Growth Stage Configurations in High-Technology Organizations*. Entrepreneurship: Theory and Practice 18(2).

14. Hannan MT & Freeman J (1977) *The Population Ecology of Organizations.* The American Journal of Sociology 82(5): 929-964.

15. Kazanjian RK and Drazin R (1989) *An empirical test of a stage of growth progression model*, Management Science, 35 (12): 1489–1503.

16. Levie JD and Lichtenstein BB (2010) A terminal assessment of stages theory: introducing a dynamic states approach to entrepreneurship. Entrepreneurship Theory and Practice, 34 (2): 317-350.

17. McClelland DC (1961) The achieving society. Princeton, Van Nostrand.

18. Miller D & Friesen PH (1984) *A Longitudinal Study of the Corporate Life Cycle.* Management Science 30(10): 1161-1183.

19. Muhos M (2011) Early stages of technology intensive companies. Oulu, University of Oulu.

20. Muhos M, Kess P, Phusavat K & Sanpanich S (2010) *Business growth models: review of past 60 years.* International Journal of Management and Enterprise Development 8(3): 296-315.

21. Muhos M, Kess P, Distanont A, Phusavat K, Sanpanich S (2014a) *Early Stages of Technology-Intensive Companies in Thailand and Finland.* International Journal of Economics and Business Research (IJEBR) Special Issue on Entrepreneurship in Emerging Markets: Firm Formation, Firm Growth, and Firm Transformation. 7(2): 177-197. (in press)

22. Muhos, M., Lee, T-R., Chang, S. Kess, P. (2014b) Growth strategies in early-stage technology-based ventures. In: Yu, T., Yan, H-D. The Handbook in East Asia Entrepreneurship. Routledge, pp. xx-xx (in press)

23. Nelson RR & Winter SG (1982) An Evolutionary Theory of Economic Change. Cambridge, Belknap Press.

24. Penrose ET (1959) The Theory of the Growth of the Firm. New York, JohnWiley&Sons.

25. Phelps R, Adams R and Bessant J (2007). *Life cycles of growing organizations: A review with implications for knowledge and learning*. International Journal of Management reviews 9(1):1-30.

26. Salonen A (1995) International growth of young technology-based Finnish companies. Helsinki, Finnish Academy of Technology.
27. Sandberg WR & Hofer CW (1982) *A strategic management perspective on the determinants of new venture success.* In: Vesper KH (ed) Frontiers of Entrepreneurship Research. Wellesley, Babson College: 204-237.
28. Stauss B & Weinlich B (1997) *Process-oriented measurement of service quality.* European Journal of Marketing 31(1/2): 33-55.
29. Storey DJ & Tether BS (1998) *Public policy measures to support new technology-based firms in the European Union.* Research Policy 26(9): 1037-1057.
30. Tesfaye B (1997) *Patterns of Formation and Development of High-Technology Entrepreneurs.* In: Jones-Evans D & Klofsten M (eds) Technology, Innovation and Enterprise - The European Experience. London, MacMillan: 61-106.
31. Wiklund J (1998) Small Firm Growth and Performance: Entrepreneurship and Beyond. Jönköping, Jönköping University, Jönköping International Business School.
32. Williamson OE (1975) Markets and hierarchies: analysis and antitrust implications: a study in the economics of internal organization. New york, Free Press.
33. Yin RK (1989) Case study research: Design and methods. Beverly Hills, Sage Publications.

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Appendix 1: The main themes of the questionnaire and interview

A. Preliminary part - in written form
A1. Company related information
A2. Interviewee related information
A3. Evaluation of the company growth related to the industry average
A4. Self-categorisation of the current stage of growth
B. Interview
B1. Introduction of the interviewer, universities and the purpose of the interview
B2. Overall description of company growth and the general effect of growth to persons own area of responsibility
B4. Description of the positive growth related incidents in relation to stages of growth and the key problem areas
B5. Description of the negative growth related incidents in relation to stages of growth and the key problem areas
B6. Conclusion

RAPID PRODUCTISATION - PRODUCT AND PRODUCT DATA OWNERSHIP

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ABSTRACT

Purpose: Rapid productisation is a special case, an exception to a company's normal product portfolio, a set of activities during which a company swiftly forms a conception over a gap product, and considers its feasibility. This type of exception can constitute a part of existing product/service/solution, not an entire product. When a customer's request is unique and is not consistent with company's portfolio strategies, product and product data ownerships become important considerations as product data is required to produce, sell, deliver, and invoice a product. The purpose of this study is to clarify requirements for product and product data ownership in the case of rapid productisation. This article aims to report the state-of-the-art of product and product data ownership in rapid productisation case by presenting a review of currently available literature.

Design/methodology/approach: The methodology consists of identifying relevant publication databases, searching these using a wide range of key words and phrases associated with product and product data ownership and rapid productisation, and reviewing the articles from the chosen perspective. The key findings and their implications for research are described.

Findings: This study presents requirements for product and product data ownership in the case of rapid productisation, including; who should own the product data; whether product ownership should be centralised or decentralised; and what are the essential aspects to be

considered upon deciding on the ownerships. This article clarifies product and product data ownership concerns for the case of rapid productisation.

Research limitations/implications: The limitations of this study include the availability of detailed information in the existing literature on the studied topic. Also, rapid productisation, product and product data ownership are not extensively discussed in the literature. However, these concepts have significant potential value for companies and practitioners in addressing their product management concerns.

Originality/value: The authors have not identified similar studies on rapid productisation, product and product data ownership. This article provides a useful review of rapid productisation, product and product data ownership. The findings can act as a platform for basing more in-depth research into the topic of managing product portfolio exceptions and related product data by providing linkages to other relevant research.

Keywords: Rapid productisation; Product data management; Product data ownership; Product management; Literature review; Product portfolio.

INTRODUCTION

Successful business operations require a high-level understanding of products and related product data (Otto, 2012; Kropsu-Vehkapera *et al.*, 2011). A vast amount of data is created and handled throughout a product's life-cycle; companies are even required to keep product data in their systems after a product is removed from the portfolio (Saaksvuori and Immonen, 2008, Ameri and Dutta, 2005). Products, or solutions, can constitute of a complex mix of tangible and intangible elements including a marketable combination of hardware, software, and services (Bitran and Pedrosa, 1998; Wise and Baumgartner, 1999). Hence, the importance of product and product configuration know-how is increasing, also due to the growing number of products and services, and tools that define and depend on product data, and configuration logic (Ackermann and Eichelberg, 2004).

During order acquisition, sales typically discusses with the potential customer what the company can offer, how these offerings meet specific customer needs, and on what price and delivery terms the transaction is possible (Trentin *et al.*, 2011). In a normal situation, the customer can pick from a set of design options (Amaro *et al.*, 1999) that are available in the company's product configurator, describing all possible product alternatives (Steger-Jensen and Svensson, 2004). A sales situation is often supported by the knowledge of the sales people (Trentin *et al.,* 2012) and products are available to sell only once they have been uploaded into company's product configurator (Bramham and MacCarthy, 2003).

It is vital that product variants that cannot be produced, ones that would not work, or cannot be delivered at the quoted price within the promised time-frame are not sold (Trentin *et al.*, 2011; Heiskala *et al.*, 2007). Incorrect orders and product data, typically translate into delays and inefficiencies (Salvador and Forza, 2004). Order acquisition and fulfilment are challenged by the high information-processing needs caused by offering a wide variety of predefined and/or tailored product variants (Forza and Salvador, 2008).

Occasionally, customers make non-standard request for products that partially differ from company's product offering, containing minor modifications or elements that are not described by product configurators. If the company is willing to consider offering such gap products, an understanding over the request is required to decide whether it is feasible to make an exception and provide a product/service/solution that differs from the regular offering. (e.g. Hänninen *et al.*, 2013; Hänninen *et al.*, 2014a; Kangas *et al.*, 2013; Kinnunen *et al.*, 2014). The activities relevant to forming a conception over a gap product, and considering its feasibility are also referred to as rapid productisation (Hänninen *et al.*, 2013; Hänninen *et al.*, 2014a; Kangas *et al.*, 2013; Kinnunen *et al.*, 2014).

Situations, triggered by a non-standard request, necessitate for mechanisms to provide rapid effective quotations, and capabilities of identifying any constraints preventing a company to tender (Bramham *et al.,* 2005). Non-standard requests ought to be considered carefully as providing customers outside the existing product range may lead in product overpopulation and cause expenses far greater than the gains obtainable via the achieved extra sales (e.g. Kotler, 1965). Providing outside the modelled product portfolio may also indicate that the company has difficulties in determining the needs of its target market (Bramham and MacCarthy, 2004). Introducing new product variants can result in unnecessary portfolio complexity resulting in many potential complications (e.g. Close *et al.*, 2008; Erens and Verhulst, 1997). Even the existing, pre-designed product variants can enable hundreds of thousands different configurations making product data management challenging (Kropsu-Vehkapera *et al.*, 2011). Nevertheless, reactively meeting customer needs at a local level, without introducing new products to the portfolio is seen to enable competitive advantages, aside sales (Marklund, 2010).

Even in a normal situation, product data is multi-dimensional and difficult to manage due to complexity of products, volume of offerings, bundled offering structures, and regulatory requirements (Srinivasan and Gnanapriya, 2009). Even the reuse of product, customer, application and process information for creating customer solutions is seen as a challenge (Bramham *et al.*, 2005). In an attempt to manage the situation, companies can define *data ownership* based on business responsibilities, often making the person creating a piece of data also the owner (Kropsu-Vehkapera *et al.*, 2009). Also other logics for assigning data ownerships exist (e.g. Supica and Pavic, 2012; Otto, 2011; Weber *et al.*, 2009). Inadequately defined data ownership, lack of continuous data quality practices,

and incoherent data management are currently amongst the greatest data management challenges (Silvola *et al.*, 2010). Defining product and product data ownership is identified as a challenge for companies (Kropsu-Vehkaperä, 2012). The literature has not widely acknowledged the impact of non-standard requests, requiring rapid productisation, from the perspective of product, and product data management.

The purpose of this study is to clarify requirements for product and product data ownership in the case of rapid productisation. This article aims to report the state-of-the-art of product and product data ownership for rapid productisation by presenting a review of currently available literature.

The above discussion can condensed to the following research question:
RQ 1: What is rapid productisation?
RQ 2: What are the essential aspects to consider upon deciding on product and product data ownership in the case of rapid productisation?
The research questions are answered based on literature findings.

METHODOLOGY

The methodology utilised in this study consists of identifying relevant data sources and publication databases, and searching these using a wide range of key words and phrases associated with product and product data ownership, and rapid productisation. The extensive literature review was conducted to better understand rapid productisation, product and product data ownership, and to gather potential previous research findings relevant to clarifying requirements for product and product data ownership in the case of rapid productisation. The existing literature was carefully reviewed and analysed to find answers to the set research questions.

At first, a broad set of data sources and publication databases were identified to ensure adequate publication coverage. The databases searched include Google Scholar, Scopus, Emerald and Science Direct. To ensure coverage, also internet searches were conducted using similar procedure as with the databases. The searches provided access to a variety of sources including journals and other publications. Journal publications were the preferred source, due to them being considered as higher level publication mediums. However, the search was not limited to journals, but also books, business periodicals, conference proceedings and other written material were utilised when necessary. The publication forum was used as a quality criterion, based on the premise that journals normally publish higher quality papers. Keywords that were associated with rapid productisation, product and product data ownership were identified (e.g. *productisation, rapid productisation, data quality, product data, product data management, non-standard product, non-standard request, local, global, centralisation, decentralisation, data governance, quotation process, rapid effective quotation, customisation, mass customisation, demand management, exception handling, product*

configurator, order acquisition, customer relationship management, master data management, change management, product management, product portfolio, data ownership, and such). Many of these key words were combined with "product" to ensure their relevance to this study. The set of keywords were expanded and refined as relevant articles were discovered. Both transatlantic forms of the keywords were utilised when different spellings exist. The utilised keywords were expected to appear in the articles. Should the keywords not appear in the actual discussion, the article was not analysed further. Once articles were identified, their references were reviewed to aid in locating additional papers, resulting in some beneficial findings. Found articles were carefully read to understand their content and analyse their contribution to the research questions and aims. By searching the chosen databases, using the keywords, a large number of articles were found. Any duplicates and non-relevant articles were discarded. The findings were filtered to 138 documents that were relevant to the research focus. The reference list to this article contains these articles. Although there is always the possibility that some articles have been missed, the reviewed articles constitute a reasonably representative body of published research work relevant to the focus of this article. The key findings and their implications for research are synthesised as it is the analysis of the found articles that forms the basis of the findings in this article.

LITERATURE REVIEW

Reflections on rapid productisation

The term *rapid productisation* can be considered to be coined by the product excellence research group of University of Oulu (e.g. Hänninen *et al.,* 2013; Hänninen *et al.,* 2014a; Hänninen *et al.,* 2014b; Hänninen *et al.,* 2014c; Hänninen *et al.,* 2014d; Kangas *et al.,* 2013; Kinnunen *et al.,* 2014) to cover activities required to form a conception over a gap product once customer enquires whether the company is willing to make an exception and provide a product/service/solution that differs by some 5-30 % of standard products. Rapid productisation can be initiated by sales when realising that a customer is not happy with the possible product configurations and requests for a gap product. During rapid productisation a company swiftly forms a conception over the gap product, whether it can be done, what are required to be able to provide it, at what cost, is it feasible for the company, and whether the company is willing to provide it. Rapid productisation does not take a position on the actual realisation of the product; it merely aims to form a conception over the requested gap product in a reasonable timeframe. This chapter reflects the existing literature against rapid productisation to reveal discussion relevant to the concept.

The direct discussion in the literature on the concept of rapid productisation is somewhat limited as also revealed by the systematic review on productisation by Harkonen *et al.*, (2013). However, some relevant discussions exist. In the literature, only few references can be found on proposal process on managing variety at the business front-end in the case of *non-standard requests* (e.g. Bramham *et al.*, 2004; Closs *et al.*, 2008). Companies may receive product requests that are outside their regular product range, ones that are not

described by their product configuration systems. These potentially non-standard products require a cooperative response from sales personnel and technical staff, whilst significant customer interactions are required to enable product specification and quotation (Bramham *et al.*, 2005). Bramham *et al.* (2004) highlights the importance of the proposal process to avoid exposing a company to serious penalties and financial losses through the lengthy support phase of an unprofitable contract, or the risk of orders being awarded to a competitor.

A company making an *exception* to its normal product offering has implications, both from the process perspective and organisational perspective. Literature presents few perspectives to exceptions, for example, exceptions can be seen as variation that must be eliminated in order to improve performance (e.g. Juran, 1986; Deming 1986), or exceptions can be seen as normal part of process flexibility as they are not necessarily errors (Strong and Miller, 1995). These two viewpoints have clear implications on management focus, performance is either improved by eliminating exceptions, or the performance of routines for handling exceptions are improved (Strong and Miller, 1995).

During *sales negotiations*, product configurators enable automated generation of products that correspond to the set of product characteristics requested by the customer (Trentin *et al.*, 2011). Ideally the same solutions can be reused systematically when the customer specifications are the same (Vanwelkenhuysen, 1988; Haug, 2010b). Typically, sales configurators are able to configure products adequately once the products are defined; changes exist only when products are uploaded into company's product configurator (Bramham and MacCarthy, 2003). In fact, company's information architecture is governed by where the product data model is maintained from, within the product configurator, or within the enterprise resource planning (ERP) system. (Bramham and MacCarthy, 2003). Salvador and Forza (2004), indicate that relying on product configuration to customise products, presents companies with difficulties, including inadequate product information supply to sales, repetitive activities by technical staff, and high rate of configuration errors in production. Errors in product configuration cause time consuming iterations between customer and supplier or between sales and manufacturing, or even production stoppages (Wright *et al.*, 1993; Forza and Salvador, 2002a).

In *a normal situation*, technical personnel do not need to support salespeople in sales specifications, as product configurators make product knowledge directly accessible (Steger-Jensen and Svensson, 2004). Negotiation support system is proposed to facilitate specification negotiations when requested products differ from specified ones, but do not involve drastic changes in design (Chen and Tseng, 2005). An integrated order fulfilment system has also been proposed, as ERP systems and Product Data Management (PDM) systems are designed to help companies streamline their business processes at a higher

strategic level rather than dealing with order fulfilment activities at a detailed operational level (Zhang *et al.*, 2010; Balogun *et al.*, 2004).

When a customer requests for something *outside the portfolio*, the product configurator will be able to provide only partial support to order acquisition activities and more information is required from the customer. The process of collecting information from customers is also referred to as elicitation, one of the key capabilities of a mass-customisation system (Zipkin, 2001). The situation can potentially be supported by salespeople's knowledge of the company's capabilities, and technicians manually generating at least part of the product data needed to build the product variant (Trentin *et al.*, 2012). However, manually generated product data will have more errors due to various reasons, such as distraction, wrong calculations, misunderstanding instructions, and such (Hvam *et al.*, 2004; Forza and Salvador, 2002a; Forza and Salvador 2002b). Aside manually generating product data, technicians also support salespeople during order acquisition while checking for product feasibility (Trentin *et al.*, 2012; Forza and Salvador, 2008; Zhang *et al.*, 2010). According to Kropsu-Vehkapera *et al.* (2011), companies have not decided clearly enough what is fixed and what can be configured, and to what extent. Sales personnel simply cannot cope with the information of a vast product portfolio. Yet, the more a company is willing to tailor its product offering to its customers, the more it is likely to experience an information processing gap in the execution of the product configuration task (Salvador *et al.*, 2007).

Literature on *mass customisation* in conjunction with *product management* indicates that some parts of mass customisation can be interpreted as rapid productisation. Especially when a company's front-end processes are required to create solutions to match the customer's needs for specification, cost, delivery and quality (Bramham *et al.*, 2005). In particular, to an extent, rapid productisation could be interpreted as *tailored customisation*, *engineering-to-order customisation*, or even *make-to-order customisation* when nominal changes are offered (Amaro *et al.*, 1999). The literature divides customisation into customised production and customised assembly (MacCarthy *et al.*, 2003). Also referred to as tailored customisation and customised standardisation respectively (Lampel and Minzberg, 1996). The point where customisation occurs can significantly influence the required effort. Duray *et al.* (2000) suggest that two variables have a central role in classifying mass customising companies: the point where the customer is involved in specifying the product and the type of modularity used in the product. The literature also has different classifications based on the required design effort, fixed or modifiable order fulfilment resources, and on whether the customisation is of one-off type or if a company is looking to gain other orders on the same specifications (MacCarthy *et al.*, 2003). In mass customisation approaches, the management of product variety and product complexity are typically supported by a product configurator (Ackermann and Eichelberg, 2004).

Product and product data ownership

This chapter reflects product and product data ownership from different perspectives to reveal potential requirements for the ownerships in the case of rapid productisation. The perspectives include: product management, product data management, product data ownership, order acquisition, data governance, data quality, stakeholders, master data management, organisational structure, and centralisation/decentralisation of organisational activities. Table 1 synthesises the discussion amongst the analysed literature streams.

Table 1 Reflections on product and product data ownership

Literature stream	Reflections on product and product data ownership
Data Quality	Assignment of data maintenance responsibilities (Haug and Arlbjørn, 2011; Loshin, 2009; Strong *et al.*, 1997)
	Roles and stakeholders (Lee and Strong, 2003; Kahn *et al.*, 2002; Loshin, 2009; van der Hoorn, 2009)
	Senior executives role in data quality issues (Redman, 1995)
	Data quality as priority when defining data ownership (Kropsu-Vehkapera *et al.*, 2009)
	Information "data" should be treated as a product that moves through an information manufacturing system, much like a physical product (Wang *et al.*, 1998)
	The aim of product data quality is not to aim at perfect data, but to ensure that quality is accurate enough in the IT systems for the aimed purpose (Orr 1998)
	Data ownership and origination must not be separated to ensure information systems sustaining high levels of data quality (Van Alstyne *et al.*, 1995)
	Input–process–output model to data quality (Lee and Strong, 2003)
Product data management	Organisation must be aligned to beat competition before PDM is useful for improving performance (Bryan and Sackett, 1997a)
	Increasing amounts of product data is retained and amended, throughout life-cycle (Kärkkäinen *et al.*, 2003)
	PDM systems to manage engineering product data, product configuration system support sales processes (Hvam *et al.*, 2011).
	Distinction between the information needed during sales, and engineering and manufacturing. Some information is the same, some different, and some overlapping (Haug, 2010a; Bryan and Sackett, 1997b)
	Ensure correct product data in all used applications ERP, PDM, CRM, product configurator (Kropsu-Vehkapera *et al.*, 2011)
	Acknowledge the impact of data having different retrieval and update frequency for sales, engineering and manufacturing (Song *et al.*, 2008)
	Product data requires discipline; avoid unnecessary copies, locations and formats. (Bryan and Sackett, 1997b)
	Appreciate product data; the data describing a product can be as valuable as the product itself (Bryan and Sackett, 1997b)
	Static and dynamic product data (Hvam, 2008; Yang et al., 2007, Stark, 2004; Kropsu-Vehkaperä, 2012; Simon et al. 2001)
	Business benefits of product data management (Sackett and Bryan, 1998)
	Understand data can have different statuses that impact the level of control and existence to company processes (Bryan and Sackett, 1997b; Lee and Suh, 2009)
	Product data views for different stakeholders (Kropsu-Vehkaperä and Haapasalo 2011; Nilsson and Fagerström, 2006; Sudarsan *et al.,* 2005, Li *et al.,* 2011)
	Distributed product data environment necessitates getting people and processes to understand product data similarly (Terzi *et al.* 2010; Liu and Xu, 2001; Post *et al.* 2002)
	Not viable to manage all possible product data, emphasis on managing data in a suitable way for each product, in each situation (Saaksvuori and Immonen, 2008; Philpotts, 1996)
	Uniqueness of every business environment and product business case, impact on PDM (Kumar & Midha , 2001)
	Different uses of product data, transferable, sharable, and managed - one representation, one IT system, and one data user (Stark, 2004)
	Acknowledge the interdependency and complexity of data ownership, product data standards, and contribution to company's business goals (Otto, 2012a)
Product data ownership	Basic principles for data ownership needed. Data responsibilities according to organisational units and related business responsibilities. Need to set responsibilities for correcting incorrect data in relevant systems (Kropsu-Vehkaperä, 2012)
	Centralised control of product data supported by technology viewpoint when cost of redundant systems, data integrity and standardising data are focal (Van Alstyne *et al.*, 1995)
	De-centralisation gives a sense of ownership, a potential incentive for creating and maintaining data. Less tangible managerial and incentive issues may play a role (Van Alstyne *et al.*, 1995)
	Determining data ownership in information systems based on natural units with clear competencies structured according to business (Supica and Pavic, 2012)
	Data owner's responsibilities, division into categories: definition of data, data quality, maintenance of data, authorisation of access, supporting user community, etc. (Loshin, 2001)
	Responsibility for data ownership and management within functional business areas through nominated individuals, acting as agents for process owners (Tull, 1997)
	Data owner, a business unit that has the responsibility and authority for a specific data set (Lucas, 2010; Lucas, 2011)
Stakeholders	Stakeholders may have similar goals, but can be driven by different motives resulting in alternate approaches (Murphy *et al.*, 2012)
	How each stakeholder group treats and uses data may have implications on communication and actions on data issues (Momoh *et al.*, 2010)

	Roles and responsibilities, steward, user, owner, data manager (Cohen, 2006)
	Responsibility assignment matric (RACI), responsible, accountable, consulted, informed, presenting cross-functional participation (Wende, 2007; Weber et al., 2009, Berger and Lewis, 2011)
	Stakeholder salience potentially impacting data issues; the degree to which managers give priority to competing stakeholder claims, a combination of three factors: power, legitimacy and urgency. (Mitchell *et al.*, 1997; Murphy *et al.*, 2012)
Data governance	Data governance, the formal orchestration of people, processes, and technology to enable organisation to leverage data as an enterprise asset (TCDII, 2006)
	Data ownership roles and responsibilities to be included as a part of individual and team performance evaluations (Karel *et al.*, 2007)
	Impact of company's culture, for instance if each business unit independently prioritises its own strategic direction, encourage decentralised data governance, where subject matter experts in different business units collaborate with each other.(Karel *et al.*, 2007)
	Data owner, a data governance role with decision rights (Weber *et al.*, 2009; Khatri and Brown, 2010)
	Data ownership requires authority (Moss, 2011; Otto, 2012b)
	The role of data owner is typically assumed by the head of the functional department/division (Otto, 2011)
Master Data Management	Master data represent the core information about a business, such as customers, suppliers, products, and the relationships between them (Dreibelbis *et al.*, 2008)
	Master data Management is an application-independent process that describes, who owns and manages core business data entities (Smith and McKeen, 2008)
	A master data object stands for a tangible business object, a product manufactured at a certain plant at certain time. Characteristics, such as colour, features, and price are specified by means of attributes. A master data class is typically specified by a data model (Loshin, 2008; Otto *et al.*, 2012)
	Master data can be divided into global and local master data. Global master data must be unambiguously defined and used throughout the company, whereas local master data typically are used in a particular country or location only (Otto, 2012b)
	Identifying roles and assigning responsibilities for managing and using data (Otto and Schmidt, 2010; Weber *et al.*, 2009)
	One size fits all approach may not be optimal due to different business requirements across divisions and functional departments, central, local, and hybrid approach (Otto, 2012b)
	One master data management framework, including data, processes and information systems (Silvola *et al.*, 2010).
	Ownership and accountability required for data, six principles (Weber and Ofner, 2008)
	Plan globally to enable operational excellence at a local level – build on existing systems (Swanton *et al.* 2007)
	Enterprise data categorised into transactional data, inventory data and master data (Kokemüller and Weisbecker, 2009)
Organisational structure	Positioning of responsibilities (Otto and Reichert, 2010)
	Treating data and data quality in the same way as physical products (Wang *et al.*, 1998)
Product management	Two approaches on mastering products, 1) central product management approach, and 2) federated product management approach (Srinivasan and Gnanapriya, 2009)
	Coordination and integration of relevant product information, throughout the entire company, is typically a task of the product management. (Ackermann and Eichelberg, 2004)
	Product management is highly impacted by company's business strategy (Saaksvuori and Immonen 2008; Khurana and Rosenthal, 1998; Baker and Hart, 2007)
Order acquisition	Close interaction is required among sales, technical office, manufacturing, and accounting to provide fast feedback to customers on product variant feasibility (Forza and Salvador, 2002a; Salvador and Forza, 2004)
	To reduce time required for order acquisition, configurable products may require allocating responsibility for collecting product specifications to sales (Forza, 2004)
	Engineering change is usually defined as a change to the form, fit or function of a product or part to satisfy customer requirements (Chen *et al.*, 2008)
Centralisation/ decentralisation of organisational activities	In a centralised organisational structure, coordination and rectifying problems occur at higher levels of hierarchy - authority to act on issues (Chen, 2007; Edgar, 2007)
	When centralised, benefits are primarily realised in stable, non-complex environments (Olson *et al.*, 2005)
	Centralisation may create a non-participatory environment that reduces communication among participants, commitment, and involvement (Chen, 2007)
	Risks of centralisation include: business inflexibility, reduced motivation, bureaucracy, and distraction. The problems created by these risks are often greater than the value created (Campbell *et al.* (2011)
	Decentralisation may decrease communication between the specialists outside of their own team, potential duplication of technical effort (Fenstermaker, 1998)
	Decentralisation refers to the degree to which decision making is pushed down to the managers who are closest to the action – more detailed knowledge on issues (Lysonski *et al.*, 1995; Tata and Prasad, 2004)
	For a complex environment with non-routine tasks decentralisation is likely to be more effective (Olson *et al.*,

2005)

From a product management perspective, generic products developed in a centralised environment may not fit specific local markets (Strieter *et al.*, 1997)

From IT management perspective decentralisation may make it difficult to enforce standards and prevent business units from sharing information due to data defined using different formats (Neirotti and Paolucci, 2007)

The most profitable companies tend to be centralised in their approach to IT governance. The fastest-growing companies are focused on innovation and time to market and insist on local accountability (Weill and Ross, 2005)

Centralisation effective at preserving corporate standards and achieving economies of scale, yet insensitive to local market conditions, slow in changes (Boström, 2008; Schlie and Yip, 2000; Campbell *et al.*, 2011; Ramdas, 2005)

Decentralised organisation may enable effective and rapid adaptation to a variety of local business situations (Boström, 2008)

Centralisation may constrain the ability to tailor products and services locally (Sloan, 1990)

Three step criterion for assessing centralisation proposals (Campbell *et al.*, 2011)

Partially-decentralised organisational structures enable managers to achieve balance between maximising company value and employee focus (Wang, 2011)

To operate effectively on the global stage requires sensitivity to local market conditions, adaptability under changing circumstances, and responsiveness to new opportunities (Boström, 2008).

Defining data ownership via multidimensional matrix in a decentralised organisation (Marklund, 2010)

A company requires a model to be able to act on non-standard requests – generaliseability of the request has an impact on relevant ownerships (Boström, 2008)

Knowledge needs impact the choice between centralisation and decentralisation (Hellström *et al.*, 2000).

DISCUSSION

Companies face situations when customers request for non-standard products that partially differ from the offering, containing minor modifications or elements that are not described by product configurators. Mechanisms are needed to consider the feasibility of providing such gap products, identify any constraints, and provide the customer an answer with a potential quotation and delivery estimates. *Rapid productisation* covers all the activities relevant to providing the answer, but does not cover any activities taking place after the potential contract with the customer. Rapid productisation should be seen as an exception rather than a normal operating procedure. An exception that potentially has implications on company's product and product data ownership. Processing requests outside company's normal product portfolio requires administrative, "manual" work, involving sales personnel, technical staff, and others. Hence, a company willing to provide non-standard products ought to consider improving the performance of routines handling these exceptions, including product and product data management.

In a normal situation customer's options are influenced by the choice of configurator rules engine, and the level of knowledge of the salesperson. However, should a company be willing to tailor its product offering to customers' needs, it is likely to experience information processing gap while executing the product configuration task. From a product configurator perspective, rapid productisation is an abnormal situation in the sense that technical personnel have to support sales people in sales specifications.

A normal product life-cycle involves phases that all require different data. Certain key elements are required to effectively manage products, and product data through the entire life-cycle, including *product data*, *product structure*, *processes* necessary for handling

product data, and *information systems* where the product data is held. These four elements must be appreciated in terms of each product life-cycle phase. Business, product management, product and product data owners all have significance for success. However, one of the fundamental starting points of considering product and product data ownerships is to truly appreciate the need for correct data.

Data ownership can ensure the quality and validity of the data. The unambiquity of data is also vital; data simply must be understandable by others to avoid unnecessary work and overlapping activities. Product data needs to be adequately distributed and needs to be available to others. In terms of rapid productisation, if processes do not exist, it is important to have some form of guideline how ownerships can be adopted. Also, one must consider whether data relevant to rapid productisation will eventually be a part of the normal process, or will it be discarded on one-off basis.

The way product and product data ownerships are assigned must be consistent regardless whether it is done based on who has the best knowledge, based on authority, or by some other means. Ownerships can be centralised, decentralised, or hybrid, combining both approaches, and can contain an ownership hierarchy with a main owner and multiple sub-owners. Centralisation is promoted by; better control, authority via higher level decisions, abiding by standards, but may result in reduced motivation, inflexibility and insensitivity to local conditions. Decentralisation, on the other hand, is promoted by sense of ownership, increased communication, decisions closer to action, understanding of local conditions, better handling of non-routine tasks, but may lack of authority. A company must decide whether the ownerships can, or is necessary to, be assigned differently in the case of rapid productisation. Other potential considerations for a rapid productisation include whether only legislation and master data issues should be acknowledged, whether there should be separate 'loose' guidelines, or whether to accept the problem and allow a mode of just getting things done, or whether to ban rapid productisation completely.

The assumption is that in the case of *rapid productisation*, it is not always possible to abide by all the company processes, or processes may not exist for such situations. If wishing to utilise existing roles, it is important for a company to be able to identify those data owners that are required for the rapid case. Should the existing roles be abandoned, a company risks creating overlapping activities that may potentially cause confusion after rapid productisation. It is also important to be able to identify, with ease, those elements/attributes of a product that the non-standard request would influence.
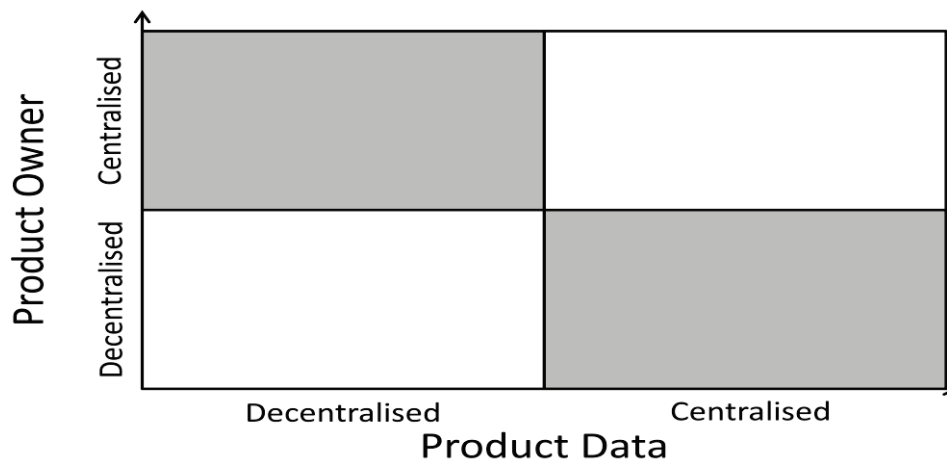
Figure 1 Relationship of product ownership and product data ownership

The relationship of *product owner*, and *product data owner*, and the model of organisation have great significance for a company (figure 1). This relationship has an impact on rapid productisation. Both functions can be either centralised (global), or decentralised, (local), resulting in four possible combinations to be considered. It may be that product ownership remains centralised, even if product data ownership is decentralised. In the case if rapid productisation, decentralisation of product data ownership may be essential to enable adequate understanding of local issues and enable adequate swiftness. However, the power to execute must be arranged by some means. From the perspective of business, product ownership may dictate the product data ownership, meaning that centralised product ownership (centralised master data management – set of basic product definition data created and maintained centrally) would entail centralised product data ownership to gain better control on the product data. On the other hand, a global product owner can have several product data teams. Local product data can be used for more advanced product definitions locally, potentially resulting in improved product data management.

The results of this study are in line with Otto (2012b) in terms of understanding that an optimum for the company as a whole is important, even if it may not always be the best solution for local units. The role of a business unit is central from the perspective of relevant expertise to understand the business validity of non-standard customer requests; this is in line with Otto and Schmidt (2010) who emphasise the importance of assessing the validity of business objects. Rapid productisation requires certain flexibility; hence local accountability to a certain extent might prove favourable from the perspective of quick decision on feasibility. This is in line with the findings of Weill and Ross (2005) who call for local accountability for those who focus on innovation and time-to-market. Also, Salvador and Forza (2004) emphasise how in order to reduce required time, product configuration favours allocating responsibility for collecting complete and

consistent product specifications to salesmen. In case of unique requests that are not consistent with company's portfolio strategies, customer interface is the natural data owner who initially considers the consequences of making an exception, and communicates with relevant parties. This is in line with the findings of Boström (2008). This article provides new viewpoints to the existing literature as the impact of non-standard requests, requiring rapid productisation, have not been widely acknowledged from the perspective of product, and product data management by the previous research.

The managerial implications of this study include shedding light on essential aspect to be considered upon deciding on product and product data ownership in the case of non-standard customer requests requiring rapid productisation. The article provides viewpoints for considering amongst centralised and decentralised product and product data management for considering the provision of gap products. The studied concepts have significant potential value for companies and practitioners in addressing their product management concerns. Efficiency is often achieved through standardisation and reducing variability. Non-standard requests have a negative impact on the gained efficiency. Hence, this study highlights the need for rapid productisation as an intentional managerial practice for addressing situations with non-standard requests, including product, and product data ownership concerns.

CONCLUSIONS

Managing Products and product data are vital for success, especially when numerous product configurations exist. Assigning product and product data ownerships is one way to better cope with multi-dimensional, complex products and product variety. Situations of non-standard customer requests during sales negotiations necessitate means to promptly consider the feasibility of offering the customer something that partially differs from the regular portfolio. This type of rapid productisation has not been widely discussed from the perspective of product and product data management. This study clarifies requirements for product and product data ownership in the case of rapid productisation by reviewing currently available literature.

The concept of *rapid productisation* covers activities that are required to form a conception over, and decide on the feasibility of non-standard customer requests for product variants. If company is willing to consider making exceptions to its product/service/solution offering, rapid productisation can be initiated by sales to consider providing products that contain minor modifications or elements not described by company's product configurators. The goal is to consider making a quotation, identify any constraints and provide information about cost and potential delivery times. The company may also need to consider when rapid productisation results in new portfolio items, and when they are one-off situations.

A company must consider whether product and product data ownership in the case of non-standard request is arranged by following the same practices and processes as in a normal case, or whether there are strong enough reasons to deviate from these. Relevant questions include: does the non-standard request entail a) something that can be done by modified assembly, b) modified production, c) something that can be done during installation, d) using 3rd party elements, e) other. This aspect, point of modification, is likely to influence the ownership considerations involved with rapid productisation. Also, the implications of rapid productisation resulting in an offering that is one-off type, versus the non-standard-request resulting in the offering becoming part of company's product portfolio must be considered. Other potential considerations include: how would the value for the organisation be the highest, and practicalities, how to get the job done the best, without generating unnecessary bureaucracy. Capability of being able to present the customer with a swift answer on whether the company is willing to provide a gap product, and on what terms, may require ability to truly understand customer wishes. This might support arguments of not separating data ownership from the creation of data. However, *adequate power* is required in some form to get the ball rolling. This can be arranged either via high level sponsorship, or assigning high level ownership. Also, the potential importance of the rapid productisation case may be a factor, aside the magnitude of the required effort. Company's existing culture will not change to support product and product data ownership in the case of exceptions, hence the culture and processes must be acknowledged. A company must carefully consider the pros and cons of choosing amongst centralisation and decentralisation on its product and product data ownership. Nevertheless, also a hybrid solution is possible to combine central and local responsibility. The value aspects of centralised and decentralised product and product data ownership must be carefully considered. Different roles relating to product and product data ownership must also be clear, both for a normal case, and for exceptions. It must be clear to what extent rapid productisation must abide by normal processes, and whether any exceptions are allowed.

Aside the availability of detailed information in the existing literature on rapid productisation, product and product data ownership, also other limitations exist. This article only analyses writings that appear in the selected databases by using a range of key words and phrases associated relevant to the studied topic. Regardless of attempts to cover all relevant literature, this article potentially ignores some relevant knowledge published. New findings might somewhat influence the results and the made conclusions.

Future research could include providing detailed practical cases and descriptions on the studied topic. Rapid productisation in the case of non-standard product requests may sometimes result in new product introductions to company portfolio, hence, also the product line pruning aspect ought to be considered. How to manage IT and data risks in the case of rapid productisation might also be interesting viewpoints worth future study.

In addition, future studies are required to clarify rapid productisation further as an intentional managerial practice for addressing non-standard requests.

REFERENCES

1. Ackermann, P. and Eichelberg, D. (2004) 'Product knowledge management, International Conference on Economic, Technical and Organisational Aspects on Product Configuration Systems Technical University of Denmark, Copenhagen.

2. Amaro, G., Hendry, L. and Kingsman, B. (1999) 'Competitive advantage, customisation and a new taxonomy for non make-to-stock companies', *International Journal of Operations & Production Management*, Vol. 19, No. 4, pp. 349-371.

3. Ameri, F. and Dutta, D. (2005) "Product Lifecycle Management: Closing the Knowledge Loops", Computer-Aided Design and Applications, Vol. 2, No. 5, pp.577–590.

4. Balogun, O., Hawisa, H. and Tannock, J. (2004) 'Knowledge management for manufacturing: the product and process database', *Journal of Manufacturing Technology Management*, Vol. 15, No. 7, pp. 575-584.

5. Berger, H. and Lewis, C, (2011) "Stakeholder analysis is key to client–supplier relationships of global outsourcing project success", *International Journal of Information Management*, Vol. 31, No. 5, pp. 480–485.

6. Bitran, G., and Pedrosa, L. (1998), "A structured product development perspective for service operations", *European Management Journal*, Vol. 16, No. 2, pp. 169–189.

7. Boström, M (2008) 'The paradox of globalization and localization at Ericsson Business Unit Networks - Enabling responsiveness in the business unit dimension when managing customized Site Solutions' Master of Science Thesis, Indek 2008:87, KTH Industrial Engineering and Management, Stockholm.

8. Bramham, J., MacCarthy, B. and Guinery, J. (2005) 'Managing product variety in quotation processes', *Journal of Manufacturing Technology Management*, Vol. 16, No. 4, pp.411-431.

9. Bramham, J., Farr, R. and MacCarthy, B. (2004) 'Learning from the proposal process used by businesses to sell customer solutions', VIVACE 2.1/UNOTT/T/07002-1.1   <available   online> [http://www.vivaceproject.com/content/engine/learnpp_full.pdf]

10. Bramham J. and MacCarthy, B. (2004) ' The demand driven chain [product configurator]', *Manufacturing engineer*, Vol. 83, No. 3, pp. 30-33.

11. Bramham, J. and MacCarthy, B. (2003) 'Matching Configurator Attributes to Business Strategy', In The 2nd world congress on mass customization and personalization, Munich.

12. Bryan, M.G. and Sackett, P.J. (1997a) 'The point of PDM [product data management]', *Manufacturing Engineer*, Vol. 76, No. 4, pp. 161-164.

13. Bryan, M. and Sackett, P. (1997b) 'Preparing for PDM [product data management]', *Manufacturing Engineer*, Vol. 76, No. 5, pp. 209-211.

14. Campbell, A., Kunisch, S. and Müller-Stewens, G. (2011) 'To centralize or not to centralize?', *McKinsey Quarterly*, June 2011, pp. 1-6.

15. Chen, C.J. (2007) 'Information Technology, Organizational Structure, and New Product Development—The Mediating Effect of Cross-Functional Team Interaction', *IEEE Transactions on engineering management*, Vol. 54, No. 4, pp. 687-698.

16. Chen, S.L and Tseng, M.M. (2005) 'Defining Specifications for Custom Products: A Multi-Attribute Negotiation Approach', *CIRP Annals - Manufacturing Technology*, Vol. 54, No. 1, pp. 159–162.

17. Chen, Y.J., Chen, Y.M. and Chu, H.C. (2008) 'Enabling collaborative product design through distributed engineering knowledge management', *Computers in Industry*, Vol. 59, No. 4, pp. 395–409.

18. Closs, D.J., Jacobs, M.A., Swink, M. and Webb, G.S. (2008) 'Toward a theory of competencies for the management of productcomplexity: Six case studies', *Journal of Operations Management*, Vol. 26, No. 5,, pp. 590–610.

19. Cohen, R. (2006) "What's in a name? Data governance roles, responsibilities and results factors", *Information Management Online*, available at: http://www.information-management.com/news/1057220-1.html (accessed 23 January 2014).

20. Deming, W.E. (1986) 'Out of the Crisis' The MIT Press.

21. Dreibelbis, A., Hechler, E., Milman, I., M., van Run, P. and Wolfson, D. (2008) 'Enterprise Master Data Management: An SOA Approach to Managing Core Information', IBM Press.

22. Duray, R., Ward, P.T., Milligan, G.W. and Berry, W.L. (2000) 'Approaches to mass customization: configurations and empirical validation', *Journal of Operations Management*, Vol. 18, No. 2, pp. 605–625.

23. Edgar, W.B. (2007) 'Corporate Library Resource Selection: Exploring Its Support for Corporate Core Competencies', *The Library Quarterly*, Vol. 77, No. 4, pp. 385-408.

24. Erens, F. and Verhulst, K. (1997) 'Architectures for product families', *Computers in Industry*, Vol. 33, No. 2–3, pp. 165–178.

25. Fenstermaker, D. (1998) 'Exploring the effect of organizational change on the management and delivery of technical service', Lehigh University, Theses and Dissertations. Paper 530.

26. Forza, C. and Salvador, F. (2008) 'Application support to product variety management', *International Journal of Production Research*, Vol. 46, No. 3, pp. 817–836.

27. Forza, C. and Salvador, F. (2002a) 'Product configuration and inter-firm co-ordination: an innovative solution from a small manufacturing enterprise', *Computers in Industry*, Vol. 49, No. 1, pp. 37–46.

28. Forza, C. and Salvador, F. (2002b) 'Managing for variety in the order acquisition and fulfilment process: The contribution of product configuration systems', *International Journal of Production Economics*, Vol. 76, No. 1, pp. 87–98.

29. Hanschke, I (2009) 'Strategic IT Management: A Toolkit for Enterprise Architecture Management', Springer.

30. Harkonen, J., Haapasalo, H. and Hanninen, K. (2013) "Productisation: a Literature Review", Proceedings of 2013 International Conference on Technology Innovation and Industrial Management 29-31 May 2013, Phuket, Thailand.

31. Haug, A. and Arlbjørn, J.S. (2011) 'Barriers to master data quality', *Journal of Enterprise Information Management*, Vol. 24, No. 3. pp. 288-303.

32. Haug, A. (2010a) 'Managing diagrammatic models with different perspectives on product information', *Journal of Intelligent Manufacturing*, Vol. 21, No. 6, pp. 811-822.

33. Haug, A. (2010b) 'A software system to support the development and maintenance of complex product configurators', *The International Journal of Advanced Manufacturing Technology*, Vol. 49, No. 1-4, pp. 393-406.

34. Heiskala, M., Tiihonen, J., Paloheimo, K.S. and Soininen, T. (2007) 'Mass customization with configurable products and configurators: a review of benefits and challenges', in: Blecker, T. and Friedrich, G. (Eds.), Mass Customization Information Systems in Business, IGI Global, London, UK, 2007, pp. 1–32.

35. Hellström, T., Kemlin, P. and Malmquist, U. (2000) 'Knowledge and competence management at Ericsson: decentralization and organizational fit', *Journal of Knowledge Management*, Vol. 4, No. 2, pp. 99-110.

36. Hvam, L., Malis, M., Hansen, B. and Riis, J. (2004) 'Re-engineering of the quotation process: application of knowledge based systems, *Business Process Management Journal*, Vol. 10, No. 2, pp. 200-213.

37. Hvam L, Mortensen N.H. and Riis, J. (2008) "*Product Customization*", New York: Springer.

38. Hvam, L., Bonev, M., Denkena, B., Schürmeyer, J. and Dengler, B. (2011) 'Optimizing the order processing of customized products using product configuration', *Production Engineering*, Vol. 5, No. 6, pp. 595-604.

39. Hänninen, K., Isoherranen, V., Kinnunen, T. and Haapasalo, H. (2014a) 'Rapid Productisation as a Strategic Choice in Small- and Medium -sized Companies', *International Journal of Management and Decision Making*, Vol. 13, No. 1, pp. 1-16.

40. Hänninen, K., Kinnunen, T., Haapasalo, H. and Muhos, M. (2013) 'Rapid productisation challenges and preconditions', *International Journal of Product Lifecycle Management*, Vol. 6, No. 3, pp. 211-227.

41. Hänninen, K., Kinnunen, T., Haapasalo, H., Saarela, M. and Muhos, M. (2014b) "Use of Rapid Productization in welfare service", *International Journal of Performance Measurement*, Accepted, Forthcoming.

42. Hänninen, K., Kinnunen, T., Haapasalo, H. and Muhos, M. (2014c) "Sales and R&D Cooperation and Integration in the Rapid Productisation Process", *International Journal of Business Process Integration and Management*, Accepted, forthcoming.

43. Hänninen, K., Muhos, M., Kinnunen, T. and Haapasalo, H. (2014d) 'Business Reasoning for Rapid Productization in Small Enterprises', *Technology and Investment*, accepted, forthcoming.

44. Juran, J.M. (1989) 'Juran on leadership for quality: an executive handbook', Free press

45. Kahn, B.K., Strong, D.M. and Wang, R.Y. (2002) 'Information quality benchmarks: product and service performance', *Communications of the ACM*, Vol. 45, No. 4, pp. 184-192.'

46. Kangas, N., Kropsu-Vehkapera, H., Haapasalo, H. and Kinnunen, T. (2013) "Empirical aspects on defining product data for rapid productisation", *International Journal of Synergy and Research*, Vol. 2, No. 1–2, pp. 107–128.

47. Karel, R., Kirby, J.P., Evelson, B., Moore, C. and Barnett, J. (2007) 'Data Governance: What Works and What Doesn't', for Information & Knowledge Management Professionals, Forrester research.

48. Kemppainen, T. (2010) 'Product data ownership network', Master''s Thesis, Department of Industrial Engineering and Management, University of Oulu, Finland.

49. Khurana, A. and Rosenthal, S.R. (1998) "Toward Holistic "Front Ends" in New Product Development", *Journal of Product Innovation management*, Vol. 15, No. 1, pp. 57-74.

50. Kinnunen, T., Hanninen, K., Haapasalo, H. and Kropsu-Vehkapera, H. (2014) "Business case analysis in rapid productisation", *International Journal of Rapid Manufacturing*, accepted, forthcoming.

51. Kotler, P. (1965) 'Phasing out weak products', *Harvard Business Review*, Vol. 43, No. 2, pp. 107-118.

52. Kropsu-Vehkapera, H., Haapasalo, H., Jaaskelainen, O. and Phusavat, K. (2011) 'Product Configuration Management in ICT Companies: The Practitioners' Perspective', *Technology and Investment*, Vol. 2,, No. 4, pp. 273-285.

53. Kropsu-Vehkaperä (2012) 'Enhancing understanding of company-wide product data management in ICT companies', Acta universitatis ouluensis, C Technica 418.

54. Kropsu-Vehkapera, H., Haapasalo, H., Harkonen, J. and Silvola, R. (2009) 'Product data management practices in high-tech companies', *Industrial Management & Data Systems*, Vol. 109, No. 6, pp. 758-774.

55. Kropsu-Vehkapera, H., Haapasalo, H., Lokkinen, S. and Phusavat, K. (2011) 'The influence of product complexity on order handling process', *Int. J. Innovation and Learning*, Vol. 10, No. 2, pp.123–143.

56. Kropsu-Vehkapera, H. and Haapasalo, H. (2011) "Defining product data views for different stakeholders", *Journal of Computer Information Systems*, Vol. 52, No. 2, pp. 61–72.

57. Kumar, R. and Midha, P.S. (2001) "A QFD based methodology for evaluating a company's PDM requirements for collaborative product development", *Industrial Management and Data Systems*, Vol. 101 No. 3/4, pp. 126-131.

58. Kärkkäinen, M., Ala-Risku, T. and Främling, K. (2003) 'The product centric approach: a solution to supply network informationmanagement problems?', *Computers in Industry*, Vol. 52, No. 2, pp. 147–159.

59. Khatri, V. and Brown, C.V. (2010) 'Designing data governance', *Communications of the ACM*, Vol. 53, No. 1, pp. 148-152.

60. Kokemüller, J. and Weisbecker, A. (2009) 'Master data management: products and research', In Proceedings of the Fourteenth International Conference on Information Quality (ICIQ), Potsdam, Germany, pp 8-18.

61. Lampel, J. and Mintzberg, H. (1996) 'Customizing customization', *Sloan Management Review*, Vol. 38, No.1, pp. 21–30.

62. Lee, Y.W. and Strong, D.M (2003) 'Knowing-Why about Data Processes and Data Quality', *Journal of Management Information Systems*, Vol. 20, No. 3, pp. 13-39.

63. Lee, Y.W., Strong, D.M., Kahn, B.K. and Wang, R.Y. (2002) 'AIMQ: a methodology for information quality assessment', *Information & Management*, Vol. 40, No. 2, pp. 133–146.

64. Lee, B.E. and Suh, S.H. (2009) "An architecture for ubiquitous product life cycle support system and its extension to machine tools with product data model", *International Journal of Advanced Manufacturing Technology,* Vol. 42, No. 5-6, pp. 606–620.

65. Li, Y., Wan, L. and Xiong, T. (2011) "Product data model for PLM system", *The International Journal of Advanced Manufacturing Technology*, Vol. 55, No. 9-12, pp. 1149-1158.

66. Lin, S., Gao, J., Koronios, A. and Chanana, V. (2007) 'Developing a data quality framework for asset management in engineering organisations', *Int. J. Information Quality*, Vol. 1, No. 1, pp.100–126.

67. Liu, D.T. and Xu, X.W. (2001) "A review of web-based product data management systems", *Computers in Industry, Vol.* 44, No, 3, pp. 251-262.

68. Loshin, D. (2009) 'Master Data Management', Morgan Kaufmann, Burlington, MA.

69. Loshin D. (2008) 'Master data management', Morgan Kaufmann, Burlington, MA.

70. Loshin, D. (2001) 'Enterprise Knowledge Management: The Data Quality Approach', Morgan Kaufman, Academic Press, San Diego.

71. Lucas, A. (2010) 'Corporate data quality management in context', Proceedings of the 15th International Conference on Information Quality, Little Rock, USA.

72. Lucas, A. (2011) 'Corporate Data Quality Management: Towards a Meta-Framework', IEEE Management and Service Science (MASS) International Conference, pp. 1-6.

73. Lysonski, S., Levas, M. and Lavenka, N. (1995) 'Environmental uncertainty and organizational structure: a product management perspective', *Journal of Product & Brand Management*, Vol. 4, No. 3, pp. 7-18.

74. MacCarthy, B., Brabazon, P.G. and Bramham, J. (2003) 'Fundamental modes of operation for mass customization', *International Journal of Production Economics*, Vol. 85, No. 3, pp. 289–304.

75. Marklund, M. (2010) 'Cross-functional product information process in a decentralized organization', Master's Thesis in Business Administration, MBA programme, Blekinge Institute of Technology.

76. Miller, E.D., MacKrell, J. and Mendel, A. (1997) 'PDM buyer's guide: product data management systems for improving processes and products', 6th ed., CIMdata, Ann Arbor, Mich.

77. Mitchell, R.K., Agle, B.R. and Wood, D.J. (1997) 'Toward a theory of stakeholder identification and salience: Defining the principle of who and what really counts', *Academy of Management Journal*, Vol. 22, No. 4, pp. 853-886.

78. Momoh, A., Roy, R., and Shehab, E. (2010) 'Challenges in enterprise resource planning implementation: state-of-the-art', *Business Process Management Journal*, Vol. 16, No. 4, pp. 537-565.

79. Moss, L.T. (2011) 'Data Governance - Managing your data as a business asset', Method   Focus   Inc.   <Available   online> http://www.egnatia.biz/downloads/2011%20Data%20Governance%201-day%20seminar%20KBASE.pdf

80. Murphy, G.D., Hyland, P. and Kivits, R.A. (2012) 'Stakeholders' perceptions of data utility in the context of ERP outcomes', In Proceedings of : AOM2012 Academy of Management Annual Meeting: The Informal Economy, Academy of Management , Boston, Mass.

81. Neirotti, P. and Paolucci, E. (2007) 'Assessing the strategic value of Information Technology: An analysis on the insurance sector', *Information & Management*, Vol. 44, No. 6, pp. 568–582.

82. Nilsson, P. and Fagerström, B. (2006) "Stakeholder requirements in a product modelling system", *Computers in Industry*, Vol. 57, No. 2, pp. 167-177.

83. Olson, E.M., Slater, S.F. and Hult, G.T.M. (2005) 'The Performance Implications of Fit Among Business Strategy, Marketing Organization Structure, and Strategic Behavior', *Journal of Marketing*, Vol. 69, No.3, pp. 49–65.

84. Orr, K .(1998) "Data Quality and Systems Theory", *Communications of the AMC*, Vol. 41, No. 2, pp. 66-71.

85. Otto, B. (2012a) 'Managing the business benefits of product data management: the case of Festo', *Journal of Enterprise Information Management*, Vol. 25, Vol. 3, pp. 272-297.

86. Otto, B. (2012b) 'How to design the master data architecture: Findings from a case study at Bosch', *International Journal of Information Management*, Vol. 32, No. 4, pp. 337–346.

87. Otto, B. (2011) 'Organizing Data Governance: Findings from the Telecommunications Industry and Consequences for Large Service Providers, *Communications of the Association for Information Systems*, Vol. 29, No. 3, pp. 45-66.

88. Otto, B. and Reichert, A. (2010) 'Organizing master data management: findings from an expert survey', Proceeding of the 2010 ACM Symposium on Applied Computing, pp. 106-110.

89. Otto, B. and Schmidt, A. (2010) 'Enterprise master data architecture: Design decisions and options'. The proceedings of the 15th international conference on information quality, Little Rock, AR.

90. Otto, B., Huner, K.M. and Österle, H. (2012) 'Toward a functional reference model for master data quality management', *Information Systems and E-Business Management*, Vol. 10, No. 3, 395-425.

91. Philpotts, M. (1996) "An introduction to the concepts, benefits and terminology of product data management", *Industrial Management & Data Systems*, Vol. 96, No. 4, pp. 11-17.

92. Post, J.E., Preston, L.E. and Sachs, S. (2002) "Managing the Extended Enterprise: the New Stakeholder View", *California Management Review*, Vol. 45, No. 1, pp. 6-28.

93. Ramdas, K. (2001) 'Managing Product Variety: An Integrative Review and Research Directions', Darden Business School Working Paper No. 01-25, University of Virginia.

94. Redman, T.C. (1995) 'Improve Data Quality for Competitive Advantage', *Sloan Management Review*, Vol. 36, No. 2, pp. 99-107.

95. Ross, W.J., Weill, P. and Robertson, C.R. (2006) 'Enterprise Architecture as Strategy', Harvard Business Review Press, Boston, Massachusetts.

96. Saaksvuori, A. and Immonen, A. (2008) "Product Lifecycle Management",.3rd ed. Berlin, Springer.

97. Sackett , P.J. and Bryan, M.G. (1998) "Framework for the development of a product data management strategy", *International journal of Operations & Production Management*. Vol. 18, No. 2, pp. 168-179.

98. Salvador, F. and Forza, C. (2004) 'Configuring products to address the customization-responsiveness squeeze: A survey of management issues and opportunities', *International Journal of Production Economics*, Vol. 91, No. 3, pp. 273–291.

99. Salvador, F., Forza, C. and Claes, B. (2007) 'Effectiveness of the Product Configuration Task: Theory Formalization and Test', POMS 18th Annual Conference Dallas, Texas, USA.

100. Schlie, E. and Yip, G. (2000) 'Regional follows global: strategymixes in the world automotive industry', *European Management Journal*, Vol.18, No. 4, pp. 343–354.

101. Silvola, R., Jaaskelainen, O., Kropsu-Vehkapera, H. and Haapasalo, H. (2010) 'Managing one master data – challenges and preconditions', *Industrial Management & Data Systems*, Vol. 111, No. 1, pp. 146-162.

102. Simon, M., Bee, G., Moore, P., Pu, J.S. and Xie, C. (2001) "Modelling of the life cycle of products with data acquisition features", *Computers in Industry*, Vol. 45, No. 2, pp. 111–122.

103. Sloan, A. (1990) 'My Years with General Motors', Reissue ed., Crown Business, New York, NY.

104. Smith, H.A. and McKeen, J.D. (2008), 'Developments in practice XXX: master data management: salvation or snake oil?', *Communications of the Association for Information Systems*, Vol. 23 No.4, pp.63-72.

105. Song, C., Kang, M. and Wei, Z. (2008) 'Research on Model and Method for Product Data Distributed Storage in Internet/Intranet Environment', International Conference on Intelligent Computation Technology and Automation (ICICTA), Vol. 1, pp. 799-805.

106. Srinivasan, M.S. and Gnanapriya, C. (2009) 'Transformation of Enterprise Product Management for Rapid Launch of Next Generation Products', White paper, Infosys. <Available online> http://www.infosys.com/industries/communication-services/white papers/documents/telecom-product-management.pdf.

107. Stark, J. (2004) "Product lifecycle management: 21st century paradigm for product realization", New York: Springer.

108. Steger-Jensen, K. and Svensson, C. (2004) 'Issues of mass customisation and supporting IT-solutions', *Computers in Industry*, Vol. 54, No. 1, pp. 83–103.

109. Strieter, J., Gupta, A.K., Raj, S.P. and Wilemon, D. (1997) 'Product management and the marketing of financial services', *Journal of Services Marketing*, Vol. 11, No. 2, pp. 128-149.

110. Strong, D.M. and Wang, R.Y. (1997) 'Data quality in context', *Communications of the ACM*, Vol. 40, No. 5, pp. 103-110.

111. Strong, D.M., Lee, Y.W. and Wang, R.Y. (1997) '10 potholes in the road to information quality', IEEE Computer, Vol. 30, No. 8, pp. 38-46.

112. Strong, D.M. and Miller, S.M. (1995) 'Exceptions and exception handling in computerized information processes', *ACM Transactions on Information Systems*, Vol. 13, No. 2, pp. 206-233.

113. Strong, D.M. (1997) 'IT process designs for improving information quality and reducing exception handling: a simulation experiment', *Information and Management*, Vol. 31, No. 5, pp.251–263.

114. Sudarsan R., Fenves, S.J., Sriram, R.D. and Wang, F. (2005) "A product information modeling framework for product lifecycle management", *Computer-Aided Design*, Vol. 37, No 13, pp. 1399-1411.

115. Supica, Z. and Pavic, T. (2012) 'Data ownership model for a telecom company', Proceedings of the 35th International Convention, MIPRO 21-25 May. pp.1534-1538.

116. Swanton, B., Hagerty, J. and Cecere, L. (2007) 'MDM Strategies for Enterprise Applications', *Enterprise Strategies Report*, AMR research <Available online> http://boaweb.com/pdf/BOA_2007%20AMR_Report.pdf.

117. Tata, J. and Prasad, S. (2004) 'Team Self-management, Organizational Structure, and Judgments of Team Effectiveness', *Journal of Managerial Issues*, Vol. 16, No. 2, pp. 248-265.

118. TCDII (2006) Corporate Data Governance Best Practices - 2006-07 Scorecards for Data Governance in the Global 5000, The Customer Data Integration Institute. <Available online> http://www.tcdii.com/images/Data_Governance_white_paper_-_April_2006.pdf

119. Terzi, S., Bouras, A., Dutta, D., Garetti, M. and Kiritsis, D. (2010) "Product lifecycle management – from its history to its new role", *International Journal of Product Lifecycle Management*, Vol. 4, No. 4, pp. 360–389.

120. Trentin, A., Perin, E. and Forza, C. (2011) 'Overcoming the customization-responsiveness squeeze by using product configurators: Beyond anecdotal evidence', *Computers in Industry*, Vol. 62, No. 3, pp. 260–268.

121. Trentin, A., Perin, E. and Forza, C. (2012) 'Product configurator impact on product quality', *International Journal of Production Economics,* Vol. 135, No. 2, pp. 850–859.

122. Tull, P. (1997) 'Managing Data Quality Within BT: A Feasibility Study', University of Leicester MBA thesis.

123. Van Alstyne, M., Brynjolfsson, E. and Madnick, S. (1995) 'Why not one big database? Principles for data ownership', *Decision Support Systems*, Vol. 15, No. 4, pp. 267–284

124. van der Hoorn, M. (2009) 'Assessment of the Data Quality approach in Shell International Exploration & Production', Master thesis, School of Management and Governance, University of Twente, The Netherlands.

125. Vanwelkenhuysen, J. (1988) 'The tender support system', *Knowledge-Based Systems*, Vol. 11, No. 5–6, pp. 363–372.

126. Wang, R.Y. (1998) 'A product perspective on total data quality management', *Communications of the ACM*, Vol. 41, No. 2, pp.58–65.

127. Wang, R.Y. and Strong, D.M. (1996) 'Beyond Accuracy: What Data Quality Means to Data Consumers', *Journal of Management Information Systems*, Vol. 12, No. 4, pp. 5-33.

128. Wang, R.Y., Lee, Y.W., Pipino, L.L. and Strong, D.M. (1998) 'Manage your information as a product', *Sloan Management Review*, Vol. 39, No. 4, pp. 95–105.

129. Wang, Q. (2011) 'A Scenario Simulation Study of Decentralization on Architecture, Engineering and Construction Companies', Proceedings of Engineering Project Organizations Conference, Estes Park, Colorado.

130. Weber, K., Otto, B. and Österle, H. (2009) 'One Size Does Not Fit All - A Contingency Approach to Data Governance', *Journal of Data and Information Quality*, Vol. 1, No. 1, Article 4.

131. Weber, K. and Ofner, M. (2008) 'Case Study Ciba – Organizing Master Data Management', Report: BE HSG/ CC CDQ/ 11, University of St.Gallen, Switzerland.

132. Weill, P. and Ross, J. (2005) 'A Matrixed Approach to Designing IT Governance', MIT Sloan Management Review.

133. Wende, K. (2007) "A Model for Data Governance – Organising Accountabilities for Data Quality Management", 18th Australasian Conference on Information Systems, 5-7 Dec 2007, Toowoomba, Australia.

134. Wise, R., and Baumgartner, P. (1999), "Go downstream: the new profit imperative in manufacturing", *Harvard Business Review*, Vol. 77 No.5, 133–141.

135. Wright, J.R., Weixelbaum, E.S., Vesonder, G.T., Brown, K.E., Palmer, S.R., Berman, J.I. and Moore, H.H. (1993) 'A knowledge-based configurator that supports sales, engineering, and manufacturing at AT&T network systems', *AI Magazine*, Vol. 14, No. 3, pp. 69–80.

136. Yang, X., Moore, P.R., Wong, C.-B., Pu, J.-S. and Chong, S.K. (2007) "Product lifecycle information acquisition and management for consumer products", *Industrial Management & Data Systems*, Vol. 107, No. 7, pp. 936–953.

137. Zhang, L.L., Lee, C.K.M. and Xu, Q. (2010) 'Towards product customization: An integrated order fulfillment system', *Computers in Industry*, Vol. 61, No. 3, pp. 213–222.

138. Zipkin, P. (2001) 'The Limits of Mass Customisation', *MIT Sloan Management Review*, Vol. 42, No. 3, pp. 81-87.

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BUILDING A MATCHMAKING MECHANISM IN A PRAGMATIC CLOUD OPEN ENVIRONMENT

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ABSTRACT

As the era of cloud computing arrives, Taiwan government's endeavor to advance the application of cloud computing has gradually turned domestic information service providers' attentions to cloud computing markets. Cloud-based service model, virtualization technology, information security and operational service level have been thus valued than ever. When governments or enterprises choose information technology (IT) as a propeller for implementing strategies, cloud-based innovative service model makes information technology transformation more valuable, not matter they adopt cloud computing service, plan to enter cloud computing service market, face to reconcile the supply and demands, or to break regulatory barrier.

This research proposes a matchmaking mechanism for cloud computing open platform by drawing on methodologies from design science research (DSR) in order to advance the application cloud computing of government, enhance research quality and service level, and develop cloud computing industry. Fulfilling the demands of cloud computing from government trains and grows information service providers in Taiwan in reconciling the supply and demands (from empirical, verification and certification perspectives), providing one-stop shopping service, lowering the setup cost of cloud computing application, offering channels to reach business opportunities, and testing domestic cloud computer solutions.

This study aims to provide a concrete solution, through the semi-automatic information system and interfaces, to fulfill the current needs that cloud computing industry has. The research findings demonstrate the efficacy of the proposed matchmaking mechanism of cloud computing open platform for government and industries to solve reconciliation issue on the supply and demands and the suitability between developed products and the nature of cloud computing.

Keywords: Cloud Computing、Information System Cloudification、Design Science

INTRODUCTION

Cloud computing is growing rapidly, and the enormous business opportunities that it is creating are stimulating new growth opportunities in the ICT sector as a whole. With a first-class network environment, IT environment and IT hardware manufacturing sector, Taiwan is well-placed to develop cloud computing. In the process of promoting and implementing its cloud computing policy, the Taiwanese government became aware that Taiwanese information service providers had found the cost of moving information systems to the cloud to be excessively high, a problem exacerbated by the lack of cloud application proof-of-concept environments, and the shortage of cloudification support and pilot project platforms.

The aim of the present study is to use the author's involvement in cloud computing policy planning and promotion to develop a better understanding of the problems affecting the development of cloud computing in the public sector and private sector. The study proposes a mechanism for establishing a cloud computing proof-of-concept platform that could be used to promote the development of cloud computing in the public sector, thereby stimulating the growth of the cloud computing sector as a whole, with government demand being used to build up the capabilities of Taiwan's information service providers, and with the roles of proof-of-concept, validation and certification being used to help match supply and demand and provide "one-stop shopping" service, at the same time reducing the cost of cloud computing application establishment, giving access to new business opportunities, and helping to cultivate domestically-developed cloud computing solutions.

LITERATURE REVIEW

1. Cloud Computing

Cloud computing is a form of computing based upon the existence of the Internet; it uses the Internet to enable both individual users and corporate users to access services that meet their own particular needs. The technology research firm Gartner has defined cloud computing as "a style of computing where scalable and elastic IT capabilities are provided as a service to multiple customers using Internet technologies" (Plummer et al., 2009). Another widely used definition of cloud computing is that adopted by the U.S. National Institute of Standards and Technology (NIST): "Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal management effort or service provider interaction." The NIST definition lists five essential characteristics of cloud computing: on-demand self-service, broad network access, resource pooling, rapid elasticity or expansion, and measured service. It also lists four "deployment models" (private, community, public and hybrid) that together categorize ways to deliver cloud services, and three "service models":

Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS) (Hogan et al., 2011).

2. Cloud Computing Policy

In 2009, the Taiwanese government positioned cloud computing as a key strategic industry the development of which needed to be prioritized. In 2012, responding to changes in market demand and intensified international competition in terms of technology, etc., the overall strategic direction and objectives of the Cloud Computing Development Project were revised to emphasize value creation and production value, and the Project was renamed the Cloud Computing Application and Development Project; it was anticipated that, through the development of public-sector cloud computing applications, it would be possible to stimulate the continued development of Taiwan's cloud computing industry, while also planning the establishment of cloud computing service platforms to serve as matching mechanisms for supply and demand (Board of Science and Technology, Executive Yuan, 2012).

3. Information System Cloudification

With regard to the practical aspects of corporate information system cloudification and related market solutions, there have been many studies published on cloud computing adoption methods and on individual organizations' experience in this area. In the U.S., the Chief Information Officer has outlined a cloud computing development strategy for the U.S. Federal Government, to guide the adoption of cloud computing applications by Federal Government agencies; this strategy includes a cloudification decision-making framework and case studies, covering cloudification options, implementation, management procedures, and recommendations regarding flexible adjustment of adoption strategy in line with actual needs (Vivek, 2011). The U.S. Federal Government has also formulated a Federal Risk and Authorization Management Program (FedRAMP) for cloud computing in the U.S., the main aim of which is to establish a set of standard security policies for cloud computing services, replacing security assessments by individual agencies with unified security evaluation, authorization and continuous monitoring (FedRAMP, 2011).

RESEARCH METHOD

1. Action Research

Action research involves the use of qualitative methods to study the problems faced by real workers in actual work situations. With participation and involvement being used to bring about improvements, the research process is implemented through an ongoing, interactive cycle of action, reflection and evaluation; the first step is to identify problems where improvement could be made, and then to take action, and to implement continuous evaluation (Lewin, 1946; Kemmis & McTaggart, 1997).

In the present study, the researcher participated in the actual process of policy formulation and platform establishment, using interviews and observation to collect comprehensive data, and interacting with related parties, to examine the process of promoting cloud computing industry development and the analysis of relevant problems, employing actual participation and continuing improvement to explore these issues.

2. Design Science

Within the field of information systems science, there are two main paradigms: behavioral science and design science. The design science paradigm involves establishing innovative systems to expand capabilities relating to human or organizational behavior; this approach is already widely used in computer science, software engineering, and information systems development, etc. Hevner et al. use design science as the foundation for proposing a clear conceptual framework that can assist in the gradual building up of information systems – with outputs that include concepts, models, methods, and case studies – and then implement continuing evaluation of their performance (Hevner et al., 2004).

Peffer et al. (2008) developed the Design Science Research Methodology (DSRM) for information systems research. The DSRM, which constitutes a process model based on repeated examination, includes six steps: problem identification and motivation, defining the objectives of a solution, design and development of the artifact, demonstration of the artifact, evaluation of the artifact, and communication of the research.

Both the Hevner and Peffer approaches can be used to reflect the IT outputs of utilizing design science to solve problems. The present study makes use of the DSRM methodology developed by Peffer et al. to devise a design model and process model that can be utilized to create an environment for exploring solutions, something that is currently lacking in the cloud computing sector, with the aim of gradually building up a pragmatic cloud environment platform development architecture that can be employed to solve the problems of supply and demand matching and of verifying whether the products and services resulting from such matching are suitable for cloud computing, issues which have been negatively affecting the development of cloud computing.
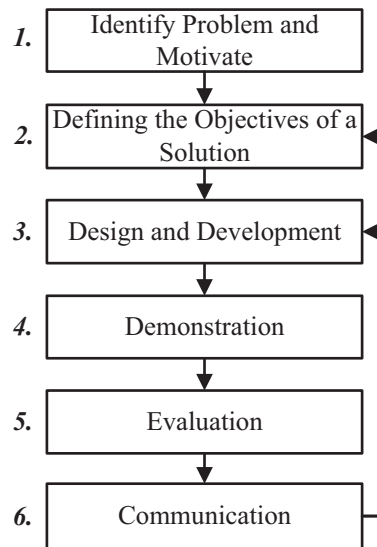
Figure 1. Research Process

RESEARCH DESIGN

The proof-of-concept environment platform design architecture developed in the present study provides a portal site for cloud-based services. The architecture facilitates the bringing together of private-sector firms' solutions, with automated uploading and virtualization; it also provides a one-stop service experience, allowing services built on cloud-based software and tools to be utilized online. The environmental architecture proposed in the present study does not involve centralized management of the related IT hardware; instead, operating and provisioning resources are accessed by network linkage, in line with cloud computing's ubiquitous, easy-access characteristics. Those users who are interested in continuing their use of a particular service can contact the service provider, and then choose the service model or solution that meets their particular needs, with the platform being used to provide verification and testing services.

1. Identify Problem and Motivate

Currently, both the public sector and private sector are working actively to plan and develop cloud computing applications and services. Whether in the case of virtualization technology or operational service management technology, etc., there is a generalized lack of understanding of cloud computing technologies and standards. In many cases, the term "cloud computing" is used to describe what are merely services provided based on existing corporate e-enablement infrastructure or websites, and there is also a tendency to hold unrealistic expectations of what cloud computing can be expected to achieve. At the same time, firms are often dubious about their ability to develop cloud computing using existing products or services; they tend to assume that cloud computing adoption inevitably involves

the allocation of substantial resources. An additional problem is the lack of environments for proof-of-concept and trial operation that can be used for testing and feedback. There is thus an urgent need for the establishment of a service environment that will make it possible for government agencies and business enterprises to experiment and implement feasibility analysis before carrying out information system cloudification, thereby helping to reduce cloud-based application development and deployment costs.

2. Defining the Objectives of a Solution

The proof-of-concept environment service platform mechanism proposed in the present study is intended to help solve the problems experienced by both public-sector organizations and private-sector firms in relation to cloud computing development; the mechanism provides a channel for exchange and matching between the supply side (private-sector firms) and the demand side (government agencies or private-sector firms). On the demand side, the mechanism facilitates the adoption of an approach in which software takes precedence over hardware, with the resources provided by the platform being used to undertake preliminary software development, thereby avoiding the situation where purchasing the IT hardware first results in being encumbered with equipment that turns out not to meet the organization's real needs, or which ends up lying idle. On the supply side, the platform will provide access to new business opportunities through trial use of new solutions, giving firms the opportunity to experiment with the cloud-based solutions that are being provided.

From the design science perspective, therefore, the aim of the present study is to establish a supply and demand matching mechanisms for public-sector applications and private-sector services, which will facilitate cloud-based application planning and proof-of-concept; technology verification will in turn help to speed up the pace of cloudification, while supporting the provision of guidance for cloud-based services and products, and using technology refinement to enhance the overall level of maturity of the services provided, thereby helping to create maximum synergy from cloud-based computing development.

3. Design and Development

The proof-of-concept environmental service platform developed in the present study will bring together a variety of different cloud-based solutions to reduce search costs for private-sector firms and implement open purchasing standards; it will provide commercialization environment resources and testing opportunities so that firms can implement service feasibility testing in advance, thereby reducing unnecessary hardware procurement and development costs, and increasing the probability than any given development project will be a success. The main functions of the platform are as follows:

(1) Proof-of-concept (POC): Recruiting private-sector firms' existing cloud computing resources (supply side) to target particular cloud-based applications (demand side), providing matching and preliminary concept feasibility verification testing service.

(2) Validation & Verification: Providing verification testing services for cloud-based

applications (demand side) that verify the special features of these applications; providing verification testing services for cloud-based service level agreements (supply side) that verify conformity with openness criteria.

(3) Certification: Providing certification and testing services, involving formal, signed documentation and/or marks or logos, in accordance with relevant cloud computing standards and rules.
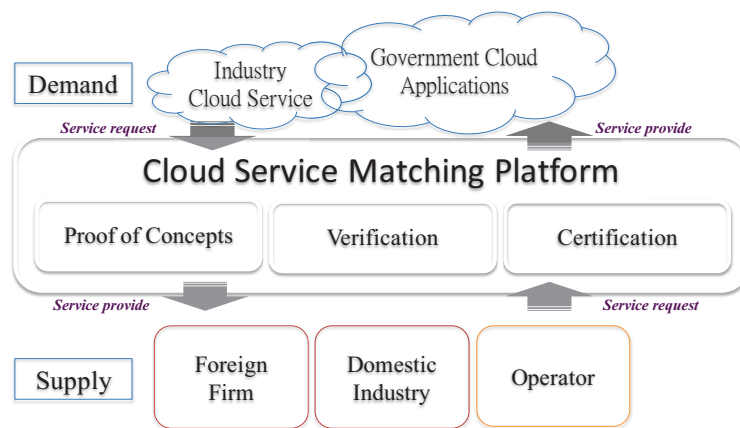
Figure 2. The proof-of-concept environmental service platform

4. Demonstration

The purpose of the proof-of-concept environment service platform established in the present study is to achieve effective linkage between supply and demand. From the demand-side perspective, the use of this platform can help to clarify the special characteristics of both domestic and overseas products; the platform's trial use mechanism and preliminary usability testing capability can serve as a useful reference for subsequent service planning, and service improvement, while also making it possible to accumulate experience in cloud-based product development experimentation. From the supply-side perspective, the platform will facilitate the provision of deployment, trial use and feature-testing services for cloud-based solutions that have already been developed, making it possible to achieve integrated usage of cloud-based solutions, and enhancing the overall level of synergy created from cloud-based products and services.

Cloud computing feature verification testing activities will include the establishment of resource directories, the planning of cloud-based application test items, implementation of cloud-based application testing, and the establishment of cloud-based application service standards. The gradual implementation of these activities will help the supply and demand sides to achieve effective methodology and process planning for cloud-based product and

services, thereby improving overall product quality and providing valuable supporting data. The evaluation items could be gradually expanded to include cloud-based application function testing and technology pilot projects, so as to enhance overall product maturity.

5. Evaluation

Before migrating information systems to the cloud, an evaluation needs to be performed – from both an operational perspective and a technical perspective – of the problems that may be encountered and the risks that will need to be borne, so as to assess whether or not it is appropriate to implement migration to the cloud. If, at this stage, it is determined that there is a high level of risk, or some unsuitability factor, then it may be necessary either to perform re-assessment or to immediately terminate the migration plans. When considering cloudification of information systems, one needs not only to consider the problems that will need to be solved and the latent potential for value creation, but also to evaluate, in terms of risk criteria, whether the necessary preparations can be made for implementing the project as an effective solution to industry's needs. Once the preliminary operational and technical confirmation has been completed, the parties involved can then move on to the demand analysis, architecture design and concept verification stages.

6. Communication

Taking into account the varying application needs of the cloud computing market in Taiwan, the Taiwanese government has been promoting the Cloud Computing Application and Development Project, which aims to use public-sector cloud-based applications with high public visibility to stimulate the development of the Taiwanese cloud computing industry, while also providing a service matching platform to serve as a channel for matching supply and demand between government agencies and cloud computing software and hardware firms.

This service matching platform, which will be using the pragmatic cloud open environment service platform mechanisms developed in the present study, has been designated the "Cloud Open Lab." In principle, government agencies that are planning to develop new cloud-based applications will no longer be encouraged to undertake related purchasing of hardware equipment; before rolling out any new system or service, they will be expected to use the service matching platform to experiment with different applications, using a development and testing approach to implement verification as to whether the various information systems and services conform to the special requirements of cloud computing (Board of Science and Technology, Executive Yuan, 2012).

CONCLUSIONS

The Cloud Open Lab is already playing an important role in the promotion of the cloud computing sector in Taiwan. As regards resource recruitment, currently more than 79 firms

have established a virtual presence in the Lab, with a combined total of 142 cloud-based services and products between them. With regard to verification and testing services, the platform provides testing facilities and testing environments, making use of a wide range of different testing scenarios to provide government agencies and cloud computing firms with the testing services they need. On the demand side, so far a total of six projects for government agencies have completed testing; the business opportunities and results created through this matching of supply and demand have won widespread praise.

In the future, once cloud-based services have been widely adopted by both government agencies and private-sector firms, service level will become a major focus of discussion between service providers and their customers, with a need to reach effective consensus regarding pricing and service quality. The ability to compare service level across different cloud-based service providers and make choices based on this comparison will become increasingly important for organizations and firms that have a need for cloud-based services.

ACKNOWLEDGEMENT

.

REFERENCE

1. Board of Science and Technology Executive Yuan (2014), ”Cloud Computing Application and Development Project”, available at http://www.bost.ey.gov.tw [accessed 1 February, 2014].

2. Gregor S. and Hevner A. R. (2013), “Positioning and Presenting Design Science Research for Maxium Impact”, *MIS Quarterly*, (37:2), pp. 337-355.

3. Hevner A. R., March S. T., and Park J. (2004), “Design Science in Information Research”, *MIS Quarterly*, (28:1), pp. 75-105.

4. Hogan, M. D., et al.(2011), “NIST-SP 500-291: NIST Cloud Computing Standards Roadmap”, *National Institute Standards and Technology*.

5. Kemmis, S., and Mctaggart, R.(1997), *The Action Research Planner*, Deakin University Press, Victoria, Australia.

6. Lewin, K. (1946), “Action research and minority problems,” *Journal of Social Issues*, (2:1), pp.34-36.

7. Peffers, K., Tuunanen, T., Rothenberger, M. A., and Chatterjee, S. (2007), “A Design Science Research Methodology for Information Systems Research”, *Journal of Management Information Systems*, (24:3), pp. 45-77.

8. Plummer, D. C., et al. (2009) , “Five Refining Attributes of Public and Private Cloud Computing”, *Gartner Research*.

9. Vivek, K. (2011), “Federal Cloud Computing Strategy”, *The US White House*.

DRIVERS FOR CONTINUANCE WITH MOBILE COMMERCE

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ABSTRACT

Purpose: *This paper reports a survey study in China in summer 2013 on continuance with mobile commerce.*

Design/Methodology/Approach: *A second-stage continuance model was developed after a thorough literature review. A survey instrument was deployed to collect data from 562 Android phone users. The model and hypotheses were empirically tested using structural equation modeling procedures.*

Findings: *Data analyses show that the salience of disconfirmation and beliefs in effort expectancy and enjoyment serves as the primary driver of the changes in satisfaction toward continuance intentions. Further, perceived effort expectancy, enjoyment and satisfaction jointly explained almost 60 percent of the variance in continuance intention.*

Research limitations/implications: *The study has a limitation for adopting a single stage cross-sectional design in spite of incorporating disconfirmation of effort expectancy and disconfirmation of enjoyment. A future longitudinal design helps examine the robustness of the model.*

Practical implications: *This study deepens understanding of the importance of perceived effort expectancy and enjoyment at post-usage stage of mobile commerce experience. It has implications for mobile commerce providers for forging continuance intentions by increasing user satisfactions and their positive attitudes. It shows that mobile commerce providers should devote more resources and efforts toward creating a truly enjoyable as well as easy mobile*

experience to increase positive disconfirmation, improve actual perceptions and boost user satisfaction.

Originality/value – An initial effort to revise and test the expanded IS continuance model in the mobile commerce context and in China. The findings on perceived effort expectancy and enjoyment in post-adoption stage of mobile commerce acceptance are considerably novel and valuable.

Keywords: Mobile commerce, continuance intention, Android, enjoyment, expectation-confirmation theory, UTAUT.

INTRODUCTION

Mobile commerce (MC), the delivery of electronic commerce capabilities directly into the consumer's hand, anywhere, via wireless technology (Duffey, 1997), is regarded "a retail outlet in your customer's pocket" in the eyes of the mobile users. Taking advantage of Wi-Fi and 4G Internet connection, smartphones allow accessing the internet very easily. A smartphone, by common understanding, refers to a small, hand-held computing device, typically having a display screen with touch input and/or a miniature keyboard and weighing less than 2 pounds. The much cheaper prices and attractive contracts on the smartphones greatly raise the affordability desired by consumers. With the simple-to-use user interfaces and recent upsurge of numerous mobile apps, people can do most things and keep in touch with their friends anywhere and anytime. MC activities on smartphone platform have become the center of attentions for business practitioners and have rapidly grown popular among mobile users. To add to those practical values, the fancy looks of smartphones make it really appealing to own and to show off in the public. All the evidence reveals one fact that mobile commerce users are growing into a critical mass in China.

With the emergence of Wi-Fi and 4G Internet supported smartphones such as iPhones, Android phones, mobile commerce expand way beyond simple data services to various free or paid owner-provided and mobile browser-based applications (of better design and more data-focused) to serve various needs (Nicolaou, 2013). On the other hand, the wireless broadband and mobile Internet today still suffer from usability problems including weak interoperability, unstable connection, latency of data transmission (Lu & Su, 2009). Mobile devices and commercial apps are constrained by batteries, memory, device, operating systems, and browser limits (Zakas, 2013). User retention and loyalty appear to be critical in determining the fate of mobile commerce (Hung, Yang and Hsieh, 2012; Kim, Lee, & Kim, 2008). It is the high time to examine the perceptions, satisfaction and continuance intentions of mobile commerce users.

Researchers have attempted to identify which antecedents are most critical to continued use and how continued use can change attitudes that have been found to be important predictors of adoption intention (Chiu & Wang 2008; Limayem & Cheung 2008). Our preliminary literature review reveals very few user continuance studies use Chinese smartphone users so far. Thus, there is some evident lack of understanding of user continuance intentions toward MC in the country where MC activities are taking a new style and popular among mobile users; lack of understanding of the factors influencing their continuance intentions.

The aim of this study is two-folded: (1) to reveal if actual usage experience impacts user perceptions toward MC; and (2) to explore if the utilitarian and hedonic determinants are both important in the decision process on continuance use of MC. As a theory guide, a process model is developed to study MC user continuance intentions. Study of this nature should yield important theoretical contributions, as well as practical implications.

THEORY BACKGROUND

Users' post-adoption behaviors have emerged as a key topic in IS research in recent years. Prior studies proposed several important theory models, including the expectation-confirmation theory (ECT), technology acceptance model (TAM), unified theory of acceptance and use of technology and its updated model (UTAUT, UTAUT2), and the latest integration of UTAUT and ECT in the expanded two-stage model of IS continuance. Those theories have one thing in common - to explain how human perceptions or beliefs are related to each other and determine IS usage for IS users. Those general models help to lay the nomological network of our research model.

ECT of IS Continuance

A key theory explaining continued IS usage is ECT of IS Continuance (Bhattacherjee, 2001). Originated in marketing to study consumer satisfaction and post-purchase Behavior (e.g. Oliver, 1980), ECT suggests that consumers first form an initial expectation of a product or service prior to purchase. After purchase and a period of use, consumers will form perceptions of the performance of the product or service bought. Next, consumers will compare the perceived performance with their initial expectations and determine the extent to which their expectations are confirmed. Finally, based on their expectation confirmation levels, consumers form a satisfaction assessment which, in turn, affects their repurchase intention. Bhattacherjee argues that IS users' continuance decisions are similar to consumers' repurchase decisions, as both types of decisions (1) follow an initial decision; (2) are influenced by the usage experience; and (3) can potentially lead to ex post reversal of the initial decision (Bhattacherjee, 2001). To highlight potential changes in users' expectation following their acceptance experience and the impact of these changes on subsequent cognitive processes, The ECT of IS Continuance model posited that

continuance intention was influenced by user satisfaction and post-acceptance perceptions, while user satisfaction was determined by confirmation of expectations from prior use. Confirmation of expectations also influenced post-usage perceptions. This revised model has been applied to studying varied problems in IS, such as IS continuance (Bhattacherjee, 2001), changes in users' beliefs and attitudes during the course of usage (Bhattacherjee & Premkumar, 2004), post-usage satisfaction (Susarla, Barua, & Whinston, 2003) and extended use of complex IS (Hsieh & Wang, 2007).

Based on the ECT of IS Continuance, Bhattacherjee and Premkumar (2004) proposed a two-stage model to study the change in cognitive beliefs (i.e. perceived usefulness and disconfirmation) and affects (i.e. satisfaction and attitude) during the course of IS usage. This two-stage model links beliefs and attitudes in the pre-usage stage with those in the post-usage stage. This model posits disconfirmation - the dissonance between users' original expectations and observed performance equivalent to confirmation in essence (Yi, 1990) and satisfaction as determinants affecting post-usage beliefs and post-usage attitudes which, in turn, influence continuance intention. This two-stage model makes it possible to capture how users' perceptions changed in the pre- and post-acceptance stages. However, perceived usefulness, a typical utilitarian belief, was incorporated as the only usage-related belief.

UTAUT and UTAUT2

Venkatesh, Morris, Davis, and Davis (2003) developed UTAUT model to consolidate previous TAM and TAM related studies. As a most mature stream of IS research, IS acceptance research through UTAUT categorize acceptance into early adoption and post adoption usage (Venkatesh, Speier, & Morris, 2007). The strength of UTAUT for explaining usage is that it allows inclusion of additional determinants besides perceived usefulness and ease of use. UTAUT has been validated using data collected in the workplace at multiple time periods, and has been supported in a number of studies using different research contexts (e.g. Park, Yang, & Lehto, 2007; Wang, Archer, & Zheng, 2006; Wang & Yang, 2005). UTAUT suggests that pre-usage beliefs may serve as anchors for post-usage beliefs as people tend to rely on their initial beliefs and early impressions in the formation of future beliefs. It is possible for those pre-usage beliefs to be disconfirmed, with such disconfirmation ultimately influencing future behavior (Venkatesh, Morris, Davis, & Davis, 2003). The focus of UTAUT is mostly on IS acceptance in workplaces. Recently, UTAUT2 (Venkatesh, Thong, & Xu, 2012) extends UTAUT by using a consumer context and by incorporating constructs beyond utilitarian considerations – hedonic motivation (equivalent to perceived enjoyment), price value and habit. Although UTAUT2 investigated continued use in mobile Internet context, the UTAUT models have not been built from an ECT perspective, and thus, not as powerful in discovering how disconfirmation of user beliefs affects changes in satisfaction or continuance intention.

Expanded Two-Stage Model of IS Continuance

Venkatesh and his colleagues extended Bhattacherjee and Premkumar's (2004) model by incorporating predictors from UTAUT such as effort expectancy, social influence, facilitating conditions and trust as a contextual belief, thus resulting in a more comprehensive set of beliefs (Venkatesh, Thong, Chan, Hu, & Brown, 2011). In line with Bhattacherjee and Premkumar's two-stage model (2004), they defined disconfirmation as the extent to which users' pre-usage expectation of IS usage is contravened during actual usage experience. According to Venkatesh and his colleagues (2011), usage experience helps to resolve the uncertainty in prior beliefs. Furthermore, disconfirmation of any of the usage-related beliefs is expected to influence satisfaction, the affective response to the degree to which expectations generated on previous occasions have been met (Oliver, 1999). This expanded two-stage IS continuance model is, thus, expected to deepen understanding of the change in cognitive beliefs during the course of IS usage from a broader perspective and generalizable and applicable to different contexts. This expanded IS continuance model was tested in a longitudinal field study of over three thousand Hong Kong citizens using e-government services (Venkatesh et al., 2011). In general, the results supported the expanded model. However, some typical predictors emerged from mobile literature are not included in this expanded continuance model.

MODEL AND HYPOTHESES DEVELOPMENT

To enhance our understanding of the post-adoption behavioral decisions toward MC usage, we've created a revised continuance model (Figure 1). Drawing on the ECT theory and the Expanded Model of IS Continuance, this revised model is a process model emphasizing the second stage concept. Instead of the well-known cognitive beliefs in those models, we emphasize two major beliefs in our research model - enjoyment from hedonic system acceptance model and UTAUT2, and effort expectancy from recent mobile technology literature respectively. Our argument is that MC activities are in fact designed to fulfill users' hedonic needs to take pleasure, in addition to satisfying their utilitarian needs to complete their commercial tasks. Thus, MC activities are both utilitarian and hedonic in nature. Effort expectancy and enjoyment emerge in recent mobile literature as two most essential drivers for behavioral decision making. Understanding whether the expected enjoyment and effort expectancy are confirmed or disconfirmed, is vital to comprehend whether user hedonic and utilitarian needs are satisfied and how post usage perceptions ultimately influence continuance intentions in mobile context. To keep in line with findings in adoption and post adoption studies, we posit the following hypotheses:

H1a: Positive disconfirmation of perceived effort expectancy has a positive influence on post-usage perceived effort expectancy.

H1b: Positive disconfirmation of perceived effort expectancy has a positive influence on satisfaction.

H1c: Post-usage perceived effort expectancy has a positive influence on satisfaction.

H1d: Post-usage effort expectancy has a positive influence on post-usage perceived enjoyment.

H1e: Post-usage perceived effort expectancy has a positive influence on post-usage attitude.

H1f: Post-usage perceived effort expectancy has a positive influence on continuance intention.

H2a: Positive disconfirmation of perceived enjoyment has a positive influence on satisfaction.

H2b: Positive disconfirmation of perceived enjoyment has a positive influence on post-usage perceived enjoyment.

H2c: Post-usage perceived enjoyment has a positive influence on satisfaction.

H2d: Post-usage perceived enjoyment has a positive influence on post-usage attitude.

H2e: Post-usage perceived enjoyment has a positive influence on continuance intention.

Satisfaction, Post-usage Attitude and Continuance Intention

Satisfaction, as an affect construct, is regarded the result of expectation-confirmation and cognitive beliefs and a predictor of post adoption behavioral decisions in the IS Continuance Model (i.e., Bhattacherjee, 2001). The two-stage model of belief and attitude (Bhattacherjee & Premkumar, 2004) posits satisfaction as an emergent construct affecting attitudes that in turn influence continuance intention. Supported by the empirical data from two longitudinal studies, Bhattacherjee and Premkumar later recommended that satisfaction be included in future process models of IT usage. The latest expanded IS continuance model (Venkatesh, Thong, Chan, Hu, & Brown, 2011) contains the constructs of satisfaction, attitude and continuance intention to help achieve their research objective. For the same reason those constructs also appear in our revised model, not as the focus of our study but as the indispensable parts of the entire model.
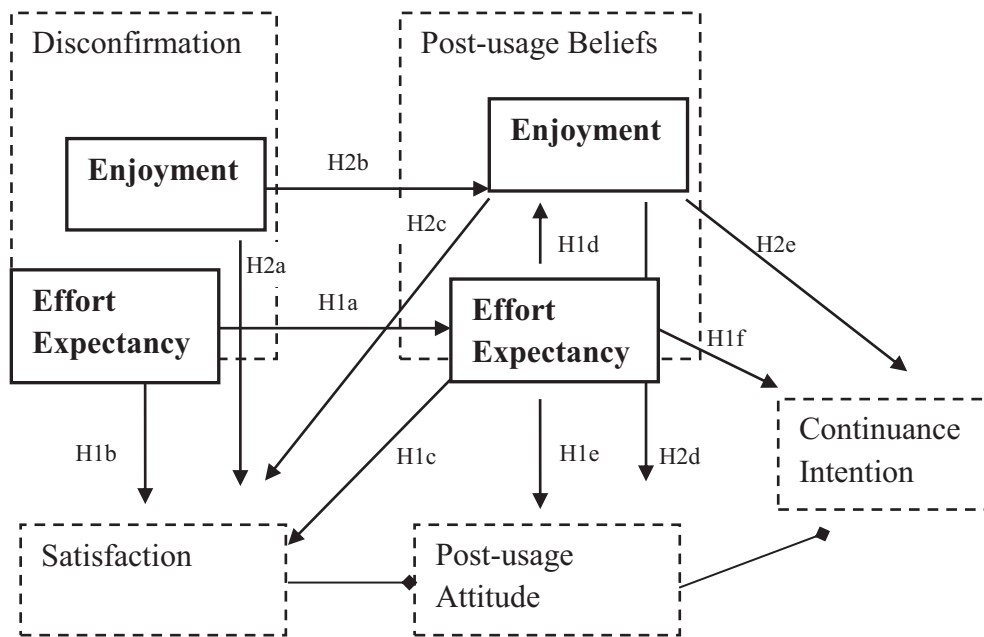
Note: Constructs and relationships under study are bolded. ----- denotes structures from prior models. ⟶◆ represents a relationship beyond the focus of this paper.

Figure 1 – A Revised Continuance Model

METHODOLOGY

Instrument Development

We used a survey instrument to collect data on mobile users' perceptions and continuance intentions toward MC. Almost all the items are adapted from those used in previous studies. Specifically, items measuring perceived enjoyment were adapted from Moon & Kim's study (2001). Items on effort expectancy were adapted from the instrument developed by Venkatesh and his colleagues (2011). Items on satisfaction, post-usage attitude and continuance intention were borrowed from the same study. The adapted items were modified to fit the context of MC that we examined. Seven-point Likert scales, with anchors ranging from 'strongly disagree' to 'strongly agree', were used for most questions to ensure consistency with previous studies, except the items measuring disconfirmation of perceptions. Those items and scales were modeled after relevant items by Venkatesh and his colleagues (2011). For easy reference, we list the items and scales used in Appendix A.

The instrument was originally in English language. To use this instrument in China, a Chinese language version was deployed after following closely the translation and back-translation process. Though most constructs in the model had been validated in previous studies,

the English version of this instrument was pilot tested in Spring 2013 using 200 MBA students from Florida, Illinois and Texas, mostly because the items on disconfirmation constructs were newly created for this study. The Chinese version was reviewed and modified among a panel of experts in May 2013. The panelists provided some very good suggestions on instrument design, item wording and format. Changes were made accordingly to suit investigation in China. The scale reliability tests revealed Cronbach alpha values of above .80 on all the model constructs.

Sample

Our target population was the voluntary users accessing MC services on their Android smartphone platform in China. Table 1 lists the demographic descriptives of our sample. Majority (88%) of our 562 survey participants was between the ages of 21 and 50, roughly in line with what was identified by Rainie (2012) that the largest mobile Internet user group of 18 to 49. The majority of the respondents had college or university education (76%), which is also in line with Rainie's description of mobile Internet users – well educated adults. Our survey covered more of managerial personnel (30.4%). Most respondents had medium level of mobility (40.7%), followed by highly mobile (33.8%) and low mobile people (25.4%).

Table 1 – Descriptives of Sample and Their MDS Uses

Variable	Frequency	Percentage (%)
Gender		
Male	466	82.9
Female	96	17.1
Age		
<= 20	26	4.6
21-30	261	46.4
31-40	185	32.9
41-50	77	13.7
>50	13	2.3
Education		
High school	90	16.0
College/University	427	76.0
Graduate	45	8.0
Occupation		
Manual worker	52	9.3
Line employee	65	11.6
Unemployed	11	2.0
Managerial	171	30.4

Variable	Frequency	Percentage (%)
Self-employed	43	7.7
Educational	48	8.5
Student	82	14.6
Professional	90	16.0
Mobility		
High	190	33.8
Medium	229	40.7
Low	143	25.4
Length of Use		
<= 1 Year	48	8.5
1-2 years	234	41.6
3-5 years	130	23.1
>5 years	150	26.7
Region		
East	212	37.7
South	124	21.1
West	64	11.4
North	77	13.7
Central	85	15.1

Data Collection

Data were collected using a nation-wide online survey in summer 2013. One thousand two hundred and ninety-six individuals participated in our survey. Among them, 573 were Android phone users. Data from 562 (43.4%) respondents using mobile commerce on Android platform were used to test the research model. Statistical packages IBM SPSS 20 and Amos Graphics 20 were used to perform scale reliability tests, factor analyses, and structural equation modeling procedures.

RESULTS

We first examined the data distribution and the general pattern of the data collected on the construct variables. All the univariate skew indexes and kurtosis values indicate a non-symmetric distribution. According to Sheng and Sheng (2012), non-symmetric distributions with positive kurtosis usually does not result in a larger alpha value than normal distribution, but probably a much smaller average of alpha with a larger SE. Since our valid sample size is 562, such non-symmetric distribution situation should not be a major concern (Hair, Black, Babin & Anderson, 2010).

In order to ensure that the variables comprising each proposed research construct were internally consistent, reliability assessment was carried out using Cronbach's alpha. Internal consistency reliability coefficients for research constructs under study are well above the commonly accepted level of 0.70 (Kline, 1999). Detailed alpha values are included in Table 2. We then conducted a principal components factor analysis adopting rotation method of varimax with Kaiser normalization. The seven factors extracted 76% of the variance.

Because the data of the constructs were self-reported and collected from a convenience sample, common method variance (CMV) could exist. In order to test the significance of the CMV, we conducted Harman's one-factor test (Harman, 1967). The results indicate that the explained variance of a single factor is about 35%. The CMV is obvious but should not be dramatic in our study. Common latent factor analysis was then conducted in Amos. The common latent factor analysis revealed a CMV of 0.06^2. This value is commonly considered very small and should not have any substantial effect on the model testing results. We, thus, proceeded with structural equation modeling (SEM) procedures to test our proposed model, without any control over CMV. Following the two-step analytical procedures (Hair et al., 2010), we first examined the measurement model and then the structural model.

The Measurement Model

We first examined the validity for all the constructs in our model using the confirmatory factor analysis (CFA). The model included 24 observable variables describing seven latent constructs: Disconfirmation of enjoyment, disconfirmation of ease of use, post-usage enjoyment, post-usage ease of use, satisfaction, post-usage attitude and continuance intention. We present the standardized factor loadings in Table 2. All were significant at the 0.001 level. The average variance extracted (AVE) for every construct was over 0.5 (Fornell & Larcker, 1981). Hence, the conditions for convergent validity were met.

Table 2 – Confirmatory Factor Analysis Results

Scale Item	Item Mean	Item S.D.	Item Loading*	Cronbach Alpha
Discon-Enjoy 1	4.84	1.487	0.797	0.905
Discon-Enjoy 2	4.85	1.268	0.855	
Discon-Enjoy 3	4.76	1.234	0.860	
Discon-Enjoy 4	4.82	1.306	0.841	
Discon-Ease 1	3.32	1.623	0.694	0.804
Discon-Ease 2	3.13	1.475	0.601	
Discon-Ease 3	3.65	1.310	0.769	
Discon-Ease 4	3.82	1.526	0.784	

Scale Item	Item Mean	Item S.D.	Item Loading*	Cronbach Alpha
Enjoyment 1	5.47	1.290	0.915	0.959
Enjoyment 2	5.40	1.339	0.935	
Enjoyment 3	5.21	1.346	0.932	
Enjoyment 4	5.29	1.242	0.900	
Ease 1	5.20	1.300	0.853	0.896
Ease 2	4.74	1.493	0.618	
Ease 3	4.95	1.408	0.811	
Ease 4	5.15	1.334	0.778	
Satisfaction 1	5.77	1.177	0.920	0.957
Satisfaction 2	5.81	1.124	0.961	
Satisfaction 3	5.83	1.133	0.929	
Attitude 1	5.27	1.218	0.910	0.949
Attitude 2	5.26	1.227	0.947	
Attitude 3	5.24	1.237	0.929	
Con-Intention 1	5.46	1.271	0.963	0.960
Con-Intention 2	5.50	1.231	0.948	

*: All item loadings reflect values significant at p < 0.001.

We also tested for the discriminant validity by comparing the square root of the AVE of each factor and the correlation coefficients with other factors, using Fomell and Larcker's (1981) criterion. The square root of the AVE was larger than the corresponding correlation coefficient between the factors, suggesting good discriminant validity (See Table 3). As the MSV values and the ASV values are less than the AVE, the constructs validity is also confirmed.

The goodness-of-fit of the overall confirmatory factor analysis (CFA) model was also examined. Since the data set contains missing data, only incremental fit indices are reported. The results showed that an adequate model fit have been achieved using the empirical data (See Table 4). We are ready to move to the next level – hypotheses testing.

Table 3: Reliability, Convergent and Discriminant Validity, and Correlation Matrix (N=562)

Factor	CR	AVE	MSV	ASV	DEN	DEE	ENJ	EFE	SAT	ATT	CIN
DEN	0.903	0.705	0.363	0.295	0.839						
DEE	0.808	0.589	0.514	0.460	0.560	0.720					
ENJ	0.958	0.856	0.174	0.144	0.310	0.240	0.925				
EFE	0.897	0.731	0.344	0.269	0.263	0.298	0.740	0.855			
SAT	0.957	0.883	0.140	0.117	0.117	0.220	0.730	0.850	0.939		
ATT	0.950	0.865	0.170	0.135	0.246	0.235	0.686	0.821	0.801	0.930	
CIN	0.958	0.920	0.092	0.079	0.228	0.293	0.642	0.672	0.676	0.644	0.959

Construct legend: DEN – Disconfirmation of Enjoyment, DEE – Disconfirmation of Effort Expectancy, ENJ – Enjoyment, EFE – Effort Expectancy, SAT – Satisfaction, ATT – Attitude, CIN – Continuance Intention.
Note: CR – Composite Reliability, AVE = Average Variance Extracted, MSV = Maximum Shared Squared Variance, ASV = Average Shared Squared Variance. Values indicating square roots of AVEs are listed diagonally in the matrix.

The Structural Model

To test our research model and hypothesized associations, we developed a path model accordingly. Specifically, we examined our proposed model fit and the hypothesized relationships by inspecting the significance and strength of hypothesized effects and comparing relative effect sizes for the dependent variables. Model indexes indicate a moderately acceptable fit (Table 4).

Table 4 –Fit Indices of the Measurement Model, the Structural Model, and Recommended Values

Fit Index	X^2/df	RMSEA	NFI	RFI	IFI	TLI	CFI
Measurement Model	2.815	.057	.955	.944	.971	.963	.971
Structural Model	2.948	.059	.950	.942	.966	.961	.966
Recommended value	< 3	<.08	>.90	>.90	>.90	>.90	>.90

Note: X^2/df – Chi square to degree of freedom ratio; RMSEA - root mean square error of approximation; NFI – Normed fit index; RFI – relative fit index, IFI – incremental fit index; CFI - Tucker-Lewis Coefficient; CFI - comparative fit index.

Results of the research model testing, including path coefficients, path significances, and variance explained (R² values) for each dependent variable, are shown in Figure 2. Regression weights of path analysis reveal that both disconfirmation of perceived EE and disconfirmation of perceived enjoyment strongly influenced the post-usage EE and post-usage enjoyment as hypothesized, but neither has any significant direct impact on satisfaction in our study. Thus,

hypotheses H1a and H2a are supported, H1b and H2b, rejected. Most hypothesized relationships regarding post-usage EE and post-usage enjoyment are supported by the empirical data, except the impact of perceived enjoyment on continuance intention. H2e is, thus, rejected. In line with the previous findings in literature, satisfaction strongly influenced post-usage attitude which, in turn, significantly influenced continuance intention. All the hypothesized causal relationships supported by this study and the variances explained are displayed in Figure 2.
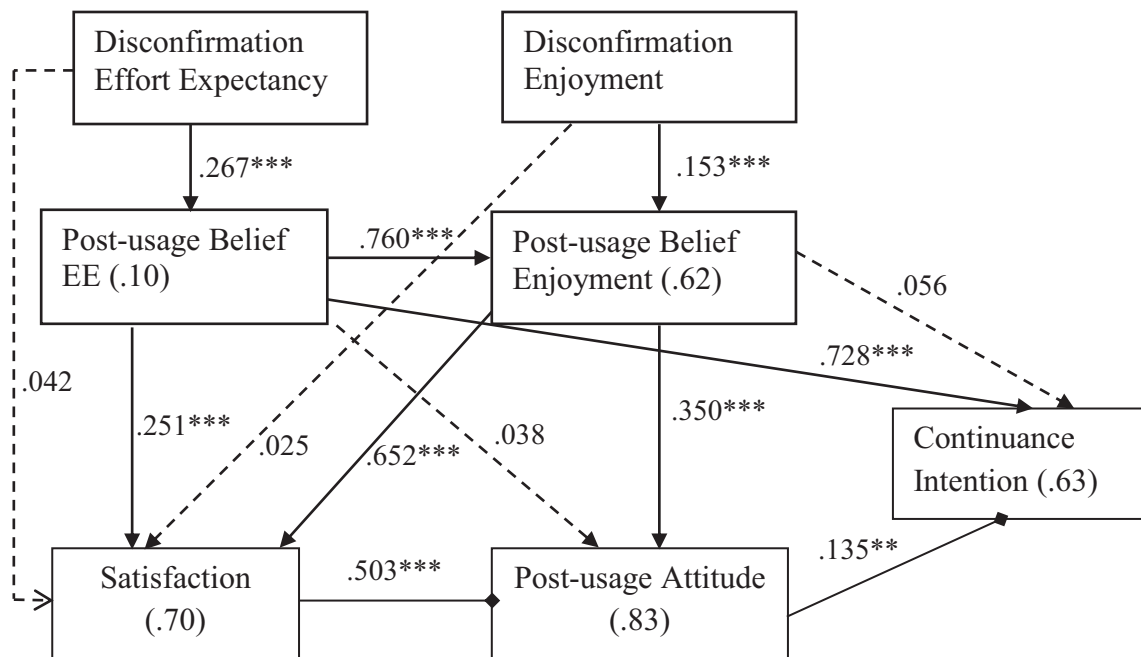
Path significances: ***p<0.001; **p<0.01; *p<.05.
Parentheses indicate R^2 values for dependent variables.
A relation not supported in the current research is represented by ‑ ‑ ‑ ‑▶
A relation not the focus of the current research is represented by ——————◆

Figure 2 – Research Model Supported by Empirical Data

The results from our study confirmed most of the hypothesized relationships in the research model -- eight were well supported by the empirical data, three were rejected (Table 5).

Table 5 - Hypotheses Testing Results

Hypothesis	Results (Estimate, SE, CR, P)
H1a: Positive disconfirmation of perceived effort expectancy has a positive influence on post-usage perceived effort expectancy.	Supported (.267, .050, 5.289, ***)
H1b: Positive disconfirmation of perceived effort expectancy has a positive influence on satisfaction.	Rejected (.042, .031, 1.344, .179)
H1c: Post-usage perceived effort expectancy has a positive influence on satisfaction.	Supported (.251, .040, 6.220, ***)
H1d: Post-usage effort expectancy has a positive influence on post-usage perceived enjoyment.	Supported (.760, .037, 9.336, ***)
H1e: Post-usage perceived effort expectancy has a positive influence on post-usage attitude.	Rejected (.040, .038, 1.049, .294)
H1f: Post-usage perceived effort expectancy has a positive influence on continuance intention.	Supported (.728, .056, 3.039, ***)
H2a: Positive disconfirmation of perceived enjoyment has a positive influence on satisfaction.	Rejected (.025, .042, .797, .426)
H2b: Positive disconfirmation of perceived enjoyment has a positive influence on post-usage perceived enjoyment.	Supported (.153, .034, 4.572, ***)
H2c: Post-usage perceived enjoyment has a positive influence on satisfaction.	Supported (.652, .042, 5.693, ***)
H2d: Post-usage perceived enjoyment has a positive influence on post-usage attitude.	Supported (.350, .051, 6.812, ***)
H2e: Post-usage perceived enjoyment has a positive influence on continuance intention.	Rejected (.056, .098, .721, .471)

For the four rejected hypotheses, we examined the indirect effects of the antecedents for mediation effects. The SEM test shows an indirect effect of .199 between disconfirmation of EE and satisfaction. Sobel 2-tailed mediation significance test reveals a very strong statistic (4.067***). The same test confirms that the indirect effect of .207 between disconfirmation of expected enjoyment and satisfaction is also highly significant (4.322***). Thus, the disconfirmation effects on satisfaction in our study were solely mediated by the post-usage beliefs. The Sobel tests also show that the indirect effect (.640) of perceived EE on satisfaction is

very significant and the influence of perceived EE is mediated onto attitude by both satisfaction and perceived enjoyment.

DISCUSSIONS

Discussion of Findings

The purpose of this paper was to reveal how actual usage experience impacts user perceptions toward MC; and to explore whether the utilitarian and hedonic determinants are both important in the decision process on continuance usage of MC.

In our study both utilitarian (i.e., EE) and hedonic constructs (enjoyment) played critical roles in predicting continuance intention toward MC via smart phones. Disconfirmation of the expectations strongly and positively affected formation of the participants' post-usage perceptions in the same areas. While both post-usage EE and enjoyment predicted satisfaction, EE had a much stronger direct impact on continuance intention, and enjoyment influenced continuance intention mostly via attitude. Perceived EE and enjoyment jointly explained 70 percent of the variance in satisfaction. The major determinants and antecedents jointly explained 83 percent of variance in attitude and 63 percent in continuance intention. Such evidence shows the strong power of our model in explaining continuance intention. Our findings seem to support the findings in Bhattacherjee's original IS Continuance Model (2001) and partially support Venkatesh and his colleagues' studies (2011, 2012) in Hong Kong. Our study confirms once more that post-usage attitude was explained jointly by satisfaction and post-usage beliefs (Oliver, 1980; Battacherjee & Premkumar, 2004; Venkatesh, Thong, Chan, Hu, & Brown, 2011). On the other hand, the strong positive influence from post-usage EE on post-usage enjoyment as shown in our study adds another piece of positive evidence that the availability of enhanced technological features (such as mobile and ubiquitous computing) tend to enhance users' perceived enjoyment (Lin & Bhattacherjee, 2010). Perceived EE and perceived enjoyment clearly are the emergent drivers of changes in post-usage perceptions which predict user satisfaction and attitude toward continued use of MC via smartphones in China. This study is one of the first to show why and how beliefs and attitude change after adoption of MC. This study, to a great extent, supports the argument made by Battacherjee and Premkumar (2004) that our beliefs, attitude, intention, and usage of IT innovations change over time as we experience IT usage first-hand and learn from such use, in turn, may change their subsequent IT usage behavior.

Unlike the findings from Venkatesh and colleagues' study (2011), satisfaction in our project was explained mainly by the post-usage beliefs, instead of disconfirmation of usage-related beliefs. These results seemed to suggest that post-usage beliefs are more critical in the formation of satisfaction. This finding is different from what's postulated in the original IT continuance model that users' extent of confirmation or disconfirmation is positively associated

with their satisfaction with IS use (Bhattacherjee, 2001). The weak direct effect of disconfirmation on satisfaction in our study suggested that one's satisfaction with IT usage is determined more by one's perceptions based on actual experience, rather than by disconfirmation of expectations of the system. Since this finding is different from most prior findings regarding disconfirmation in the continuance decision making process, more evidence is needed to ascertain the true nature of the impact from disconfirmation.

Implications for Research

This study is able to add some value to the existing literature. The potential contributions are in the following aspects:

First, this is one of the first efforts to revise and test the expanded IS continuance model in the U.S. Thus, it is able to examine, to some extent, the value of the expanded model in the context of MC. Since this study confirms and disconfirms certain hypothesized relationships, it is, thus, able to deepen our understanding of the dynamics in relative importance of various key beliefs at post-usage stage of experience.

Second, adjusting the expanded IS continuance model by highlighting the roles of EE and enjoyment are critical to the advancement of understanding MC users. This extension is in line with recent calls for incorporating constructs to aid the design of relevant interventions in different research contexts (Venkatesh, Speier, & Morris, 2007; Venkatesh & Bala, 2008).

Third, Because of the balanced attention to the utilitarian and hedonic determinants, this study has strong potential to deepen our comprehension of the subsequent influences of the selected variables after adoption in mobile context, and thus, advance our understanding of individuals' post-adoption behaviors. It should also contribute to the growing body of research emphasizing the importance of both cognitive and affective elements in IS studies.

The last, the strong ECT element in our model helps not only to examine the dynamic effects of the beliefs during the disconfirmation process, but also any crossover effects of the beliefs. For example, perceived post-usage EE had a strong direct effect on perceived post-usage enjoyment ($r = .760$); positive disconfirmation in EE indirectly improved perceived post-usage enjoyment ($r = .202$). Such speculation of how different beliefs may influence each other during the process will definitely deepen our understanding of the behavioral decision process regarding MDS continuance, and more generally the IS continuance.

Implications for Practice

This study provides some implications for managing MC on smartphone platform in practice. From a user retention perspective, MC providers can forge continuance intentions by increasing

user satisfactions and their positive attitudes with the services. For this purpose, MC providers should devote more resources and efforts toward creating a truly enjoyable as well as easy usage experience. To enable greater ease of access and use, more effort is need to enable larger network coverage, better throughput, and reduced wireless latency, and to offer more varied location-based MC services. More advanced mobile cloud computing and roaming across devices may be instrumental. Of course, higher level of mobility and ubiquitous computing is forged by collaborative effort between MC providers, mobile networking operators, and regulations and policy makers. Adequate attention should also be paid to improving the business alliances and relationship building with policy makers.

Besides, our study results were derived from responses of voluntary users of smartphone MC users. Thus, how to keep them like and enjoy the actual experience of using MC becomes another critical measure for value. The respondents in our study covered more managerial and male MC users. They were definitely different from those only adhered to playing games and downloading pop songs. Thus, bringing them enjoyable experience raises the expectations for the design of user interfaces, provision of functions and variety and substances of the MCs on the smartphone platforms. For this purpose, it is necessary for MC providers to explore seriously the causes for enjoying MC among adults, and to supply adhered services to adult users of diverse types.

In addition, our study results also have implications for adjusting and providing MC training and promotion programs. It is a very important and long term task to follow up with MC user disconfirmations of expectations and actual perceptions. For these two types of feedback are dynamic and critical to user continuance decisions. To forge positive disconfirmation of expectation and actual perceptions, instant tutoring hints should be available whenever a new version or a new service is loaded. A sense of achievement incurred leads to the feeling of rewarding and enjoyment as well.

CONCLUSIONS

The objective of this study was to validate a revised model of continuance, with a balanced attention to the utilitarian and hedonic determinants. Despite some variations between individual path coefficients, most findings corroborated our proposed model, establishing the salience of disconfirmation and beliefs in EE and enjoyment in driving satisfaction and attitude changes toward continuance intentions. We validated this revised continuance model in the MC context. The results demonstrated the roles of EE and enjoyment beliefs in predicting satisfaction and post-usage attitudes toward MC in China. Overall, the findings of this work enrich our understanding of the phenomenon of post adoption. Since 63% of the model variance was jointly explained by satisfaction, attitude, EE and enjoyment, the model is powerful in explaining MC

continuance decision among Android users, esp. when most of them are male holding managerial positions. Future research efforts should replicate to confirm our findings using different samples and in different contexts. Future efforts should also be made in cross-culture, cross-country comparisons to increase our understanding of consumer continuation intention on a global scale.

REFERENCES

1. Bhattacherjee, A. (2001). "Understanding information systems continuance: an expectation-confirmation model", *MIS Quarterly*, Vol. 25 No. 3, pp. 351-370.
2. Bhattacherjee, A., & Premkumar, G. (2004). "Understanding changes in belief and attitude toward information technology usage: a theoretical model and longitudinal test", *MIS Quarterly*, Vol. 28 No. 2, pp. 229-254.
3. Chiu, C. M., & Wang, E. T. G. (2008). "Understanding Web-based learning continuance intention: the role of subjective task value", *Information and Management*, Vol. 45 No. 3, pp. 194-201.
4. Duffey, K. (1997). "The Mobile commerce opportunity," Available at http://cryptome.org/jya/glomob.htm (Accessed on July 20, 2013).
5. Fomell, C., & Larcker, D.F. (1981). "Evaluating structural equation models with unobservable variables and measurement error", *Journal of Marketing Research*, Vol. 18 No. 1, pp. 39-50.
6. Hair, J.F., Black, W.C., Babin, B.J., & Anderson, R.E. (2010). "*Multivariate Data Analysis* (7th Ed.)", Prentice Hall, Upper Saddle River, NJ.
7. Harman, H. H. (1967), *Modern Factor Analysis*, University of Chicago Press, Chicago, IL.
8. Hsieh, J.J.P., & Wang, W. (2007). "Explaining employees' extended use of complex information systems", *European Journal of Information Systems*, Vol. 16 No. 3, pp. 216–227.
9. Hung, M. C., Yang, S. T., and Hsieh, T. C. (2012). "An examination of the determinants of mobile shopping continuance", *International Journal of Electronic Business Management.* Vol. 10 No. 1, pp. 29-37.
10. Kim, H., Lee, I., & Kim, J. (2008). "Maintaining continuers vs. converting discontinuers: relative importance of post adoption factors for mobile data services", *International Journal of Mobile Communications*, Vol. 6 No. 1, pp. 108-132.
11. Kline, P. (1999). *The Handbook of Psychological Testing* (2nd ed.), Routledge, London.
12. Limayem, M., & Cheung, C. M. K. (2008). "Understanding information systems continuance: the case of Internet-based learning technologies", *Information and Management*, Vol. 45 No. 4, pp. 227-232.
13. Lin, C. P., & Bhattacherjee, A. (2010). "Extending technology usage models to interactive hedonic technologies: a theoretical model and empirical test", *Information Systems Journal,* Vol. 20 No. 2, pp.163-181.

14. Lu, H.P., & Su, P.Y.J. (2009). "Factors affecting purchase intention on mobile shopping web sites", *Internet Research*, Vol. 19 No. 4, pp. 442 – 458.

15. Moon, J., & Kim, Y. (2001). "Extending the TAM for a World-Wide-Web context", *Information & Management*, Vol. 38 No. 4, pp. 217–230.

16. Nicolaou, A. (2013). "Best practices on the move: Building web apps for mobile devices", *Communications of the ACM.* Vol. 56 No. 8, pp. 45-51.

17. Oliver, R. L. (1980). "A cognitive model for the antecedents and consequences of satisfaction", *Journal of Marketing Research*, Vol. 17 No. 4, pp. 460-469.

18. Oliver, R. L. (1999). "Whence consumer loyalty? fundamental issues and directions for marketing", *Journal of Marketing,* Vol. 63, pp. 33-44.

19. Park, J. K., Yang, S.J., & Lehto, X. R. (2007). "Adoption of mobile technologies for Chinese consumers", *Journal of Electronic Commerce Research*, Vol. 8 No. 3, pp. 197-206.

20. Rainie, L. (2012). Changes to the way we identify Internet users, *Pew Internet & American Life Project*, available at http://pewinternet.org/Reports/2012/Counting-internet-users/Counting-internet-users.aspx (Accessed on Dec. 24, 2012).

21. Susarla, A., Barua, A., & Whinston, A.B. (2003). "Understanding the service component of application service provision: An empirical analysis of satisfaction with ASP services", *MIS Quarterly*, Vol. 27 No. 1, pp. 91–123.

22. Venkatesh, V., & Bala, H. (2008). "Technology acceptance model and a research agenda on interventions", *Decision Sciences*, Vol. 39 No. 2, pp. 273–315.

23. Venkatesh, V., Morris, M.G., Davis, G.B. & Davis, F.D. (2003). "User acceptance of information technology: toward a unified view", *MIS Quarterly*, Vol. 27 No. 3, pp. 425 – 478.

24. Venkatesh, V., Speier, C., & Morris, M.G. (2007). "User acceptance enablers in individual decision making about technology: Toward an integrated model", *Decision Sciences*, Vol. 33 No. 2, pp. 297-316.

25. Venkatesh, V., Thong, J. Y. L., Chan, F. K. Y., Hu, P., & Brown, S.A. (2011). "Extending the two-stage information systems continuance model: incorporating UTAUT predictors and the role of context", *Information Systems Journal*, Vol. 21 No. 6, pp. 527-555.

26. Wang, S., Archer, N.P. & Zheng, W. (2006). "An exploratory study of electronic marketplace adoption: a multiple perspective view", *Electronic Markets*, Vol. 16 No. 4, pp. 337–348.

27. Wang, W.T., & Li, H.M. (2012). "Factors influencing mobile services adoption: A brand-equity perspective", *Internet Research*, Vol. 22 No. 2, pp. 142-179.

28. Wang, H.I. & Yang, H.L. (2005). "The role of personality traits in UTAUT model under online stocking", *Contemporary Management Research*, Vol. 1 No. 1, pp. 69–82.

29. Yi, Y. (1990). "A critical review of consumer satisfaction, in Zeithaml", V. A. (Ed.), in Review of Marketing 1990, *American Marketing Association*, Chicago.

30. Zakas, N. C. (2013). "The evolution of Web development for mobile devices: Building Web sites that perform well on mobile devices remains a challenge", *Communications of the ACM*, Vol. 56 No. 4, pp. 42-48.

APPENDIX A: SURVEY ITEMS

Continuance Intention

As a user, I will keep on using mobile commerce.

I intend to continue using mobile commerce in the future.

Post-usage Attitude

All things considered, using mobile commerce is a positive step.

All things considered, using mobile commerce is a good idea.

All things considered, using mobile commerce is a wise move.

Satisfaction

I am contented with my use of mobile commerce.

I am pleased with my use of mobile commerce.

I am satisfied with my use of mobile commerce.

Effort Expectancy

My interaction with the selected mobile commerce service is clear and understandable.

Using the selected mobile commerce service requires little of my mental effort.

I find it easy to use the selected mobile commerce service to get what I want.

Learning to use the selected mobile commerce service is easy.

Perceived Enjoyment

Using mobile commerce brings me pleasure.

Using mobile commerce makes life fun.

Using mobile commerce makes me feel happy and relaxed.

Using mobile commerce is exciting.

Disconfirmation of Effort Expectancy

Compared to my initial expectations, _____

My interaction with the selected m-commerce service is

1) Much more unclear and much less understandable than expected

2) More unclear and less understandable than expected.

3) A little unclear and a little less understandable than expected

4) As clear and understandable as expected.

5) A little clearer and a little more understandable than expected

6) Clearer and more understandable than expected.

7) Much clearer and much more understandable than expected.

Interacting with the selected m-commerce service requires (Confirm_Ease2)
1) Much more of my mental effort than expected.
2) More of my mental effort than expected
3) A little more of my mental effort than expected
4) The same amount of mental effort as expected
5) A little less of my mental effort than expected
6) Less of my mental effort than expected
7) Much less of my mental effort than expected.

I find it _____
1. Much harder to use *the selected m-commerce service* to get what I wanted.
2. Harder to use *the selected m-commerce service* to get what I wanted.
3. A little harder to use *the selected m-commerce service* to get what I wanted.
4. The same as expected to use *the selected m-commerce service* to get what I wanted.
5. A little easier to use *the selected m-commerce service* to get what I wanted.
6. Easier to use *the selected m-commerce service* to get what I wanted.
7. Much easier to use the selected m-commerce service to get what I wanted.

Learning to use *the selected m-commerce service* is _____
1) Much more difficult than expected.
2) More difficult than expected.
3) A little more difficult than expected.
4) as easy or as difficult as expected.
5) a little less difficult than expected
6) less difficult than expected
7) much less difficult than expected

Disconfirmation of Enjoyment
Compared to my initial expectations, _____
Using mobile applications brings me
1) Much less pleasure than expected.
2) Less pleasure than expected.
3) A little less pleasure than expected.
4) As much pleasure as expected.
5) A little more pleasure than expected.
6) More pleasure than expected.
7) Much more pleasure than expected.

Using mobile applications makes life _____
1) Much less fun than expected.
2) Less fun than expected.
3) A little less fun than expected.
4) As much fun as expected.
5) A little more fun than expected.
6) More fun than expected.
7) Much more fun than expected.

Using mobile applications makes me feel _____
1) Much less happy and relaxed than expected.
2) Less happy and relaxed than expected.
3) A little less happy and relaxed than expected.
4) As happy and relaxed as expected.
5) A little happier and more relaxed than expected.
6) Happier and more relaxed than expected.
7) Much happier and much more relaxed than expected.

Using mobile applications is _____
1) Much less exciting than expected.
2) Less exciting than expected.
3) A little less exciting than expected.
4) As exciting as expected.
5) A little more exciting than expected.
6) More exciting than expected.
7) Much more exciting than expected.

INSURANCE PRODUCTS INNOVATIONS BASED ON MANAGEMENT ACCOUNTING

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ABSTRACT

This paper presents the application of management accounting in the context of innovation within insurers' products portfolio. The innovation consists in offering insurance to entrepreneurs who wish to expand their businesses and follow the idea of sustainable development and innovative product creation.

The authors are convinced that at the age of innovation, the insurance sphere, in terms of increasing competition, can remain insensitive to the need for innovation not only in the area of insurance operation of companies, but also in the area of offer submission. An innovative offer can maximize the insurer's revenue.

Product innovations give the insurer an opportunity to play an important role in contribution to sustainable development on a macroeconomic scale, or even more – on the global scale. This is due to a special insurance offer within the innovation supporting sustainable development. At the same time, in the global world the significance of so the called "new" risks such as the risks of nanotechnology or digital risks is more important and causes the need for modifications of the existing insurance cover.

The paper focuses on the concepts of management accounting. They have been chosen by the authors as being potentially useful in diagnosing various risk factors associated with the need for innovative insurance offer on the one hand and the support of innovative activity of entrepreneurs on the other.

The discussion provided by the authors is illustrated by the examples related to the production based on nanotechnology, which is said to be "the future that begins today."

The problem is considered important for every insurance company which is innovative in such a way. The weight of the problem lies mainly in the fact that insurance products or innovative actions are characterized by elevated and yet absolutely unrecognized risks. It

results from the fact that the insurance cover of unique risks, has to be concluded in situations where the insurance companies do not have any historical data to accurately quantify risk. In such cases, an insurance company has no empirical observations, which could allow for the conclusion that the risk factors associated with an innovative product of its client would be to some extent recognized, i.e. thanks to "the history of insurance of products similar to the innovative product."

The significance of the problem is growing if it is taken into account that the innovative product of the insurance company client should serve the purpose of sustainable development. This requirement imposes on an insurance company the necessity for a perfect diagnosis of a wide range of important conditions for sustainable development on a scale far greater than just the client area. In addition, these conditions are closely related to the future, when the consequences of the introduction of innovative products are not easy to predict. The problem of sustainable development even by offering products already known on the market (with the market history) is very complex. In the case of innovative products the problem becomes even more complex, and – in view of this – the authors search for tools so as to help to diagnose various risk factors which appear particularly clearly when innovation and products are to be insured, with a potential threat to sustainable development.

INTRODUCTION

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The discussion provided by the authors is illustrated by the examples related to the production based on nanotechnology, which is said to be "*the future that begins today*." [1] The problem is considered important for every insurance company which is innovative in such a way. The weight of the problem lies mainly in the fact that insurance products or innovative actions are characterized by elevated and yet absolutely unrecognized risks. It results from the fact that the insurance cover of unique risks, has to be concluded in situations where the insurance companies do not have any historical data to accurately quantify risk. In such cases, an insurance company has no empirical observations, which could allow for the conclusion that the risk factors associated with an innovative product of its client would be to some extent recognized, i.e. thanks to *"the history of insurance of products similar to the innovative product."*

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EVALUATION OF INSURANCE MARKET DEVELOPMENT IN FACE OF FINANCIAL CRISIS

Since 2007 the European financial market, which includes the insurance sector has been in a serious crisis whose consequences are discernible in the whole economy. The entities interested in activities connected with overcoming the crisis are more and more active suggesting different solutions. An example to be quoted is the Communication from the European Commission EUROPE *2020.* A Strategy for Smart, Intellectual and Sustainable Inclusive Growth." The construction of this document as a strategy is based on three priorities: intelligent development, sustainable development and social inclusion development[2].

The strategy EUROPA 2020 does not mention the risks but discusses definite activities following the aforementioned priorities, for example: the resignation from fiscal incentives, short-term support for the unemployed, application of sector support systems, enhancing

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[1] http://www.nano-technologie.pl/, accessible as of: 2014-01-12.
[2] Komunikat Komisji Europejskiej (Communication from the European Commission) „Europa 2020, *Strategia na rzecz intelektualnego i zrównoważonego rozwoju sprzyjającego włączeniu społecznemu, (Europe 2020. A Strategy for Smart, Intellectual and Sustainable Inclusive Growth),* Brussels, 3 March 2010, p. 12

safety, accounting and consumer protection principles, resignation from financial sector support or improvement of financial institutions support. These activities are inseparably accompanied by the risk whose thematic diversity (different kinds of risk distinguished) results from a specific character of the undertaken activity area.

With regard to the insurance risk, it is worth considering the suggested scenarios of overcoming crisis from the perspective of the role which the insurance sector may play in their implementation. Bearing in mind the idea of such documents as the aforementioned strategy, it may be worth perceiving the insurance sector not as a lifebelt which, through the product offer, implements the main goal of insurance (the elimination of worries and fears related to the financial effects of random incidents – risk realisation) but as one of many business entities affected by the crisis, a sector component of the financial system. In the next section of the article we present the results of research of the development and innovativeness of the insurance sector. The results empirically confirm a weak innovativeness especially in within the product offer through which insurance companies could stimulate economic growth. At the same time, as indicated in section 3 of the text, there is a growing significance of the so-called new risks such as digital risk and nanotechnology or cascading catastrophes related risk. The risk connected with the application of nanotechnology is interesting and challenging for the sector of insurance. The danger and threat created by nanotechnology is relatively new[3]. Insurance companies do not have at their disposal a sufficient number of historical observations allowing for the quantification of risk. Thus, in the last section of the article we consider a possibility of application of a selected management accounting concept known as *learning curve*, which in our opinion may be used in an innovative way in order to support the process of creation of new insurance services allowing for the protection against the realisation of risk whose evaluation in a traditional way is difficult. The presentation of this concept as a tool supporting the evaluation of insurance risk connected with the insurance protection of innovative companies applying high tech production technologies is preceded by the results of research conducted in the SGH Department of Insurance and Risk showing a low level of product innovativeness of the insurance sector in Poland and in Europe.

The description of research and methodology applied

This study uses two groups of measures: the distance measure and similarity measure. Measure μ describing the degree of similarity between dimension structures of the two objects is defined by the following equation:

$$\mu_{i,p} = \frac{z_i \,^{\circ} z_p}{|z_i||z_p|}$$

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[3] The beginning of nanotechnology dates back to the 1950s, when Richard Phillips Feynman delivered a lecture entitled *There's Plenty Room at the Bottom* for the American Physical Society in Pasadena. See example: http://www.pa.msu.edu/~yang/RFeynman_plentySpace.pdf, accessible as of: 2014-01-12.

Where: $z_i \circ z_p$ denotes the scalar multiple of vectors z_i and z_p containing all dimensions of the particular objects and $|z|$ the length of the vectors. This means that the value of the μ is between -1 and 1 as the scalar multiple is the cosine of the angle between the vectors.

The measure of similarity of objects dimensions $d*(i,p)$ is defined by the following equation:

$$d*(i,p) = 1 - \frac{1}{2\sqrt{kn}} * d(i,p) ,$$
$$0 \leq d*(i,p) \leq 1$$

where: k denotes the number of objects and n denotes the number of dimensions, is a normalized version of the differentiation of objects' dimensions $d(i,p)$.

$$d(i,p) = \sqrt{(\sum_{i=1}^{k}(z_{i,i} - z_{i,p})^2)}$$

where: d_{ip} denotes the distance between objects i and p and $z_{ij}z_{pj}$ the values of dimension j of object i and p respectively.

The research was conducted by means of the multidimensional statistical analysis. The comparative approach made use of taxonomic procedures. The analysis of the development of the insurance sector was conducted in relation to four groups of features: *market structure, technical sphere, finance and investment, effectiveness, products* (see Figure 1). In each group there was a set of diagnostic features. Before the beginning of research the database was created including the implementation of selected diagnostic features in the years 1997 and 2010. Eventually, the number of features was decided after the analysis of correlations between them; whereas the point of observation was determined on the basis of the implementation of features from all the groups.
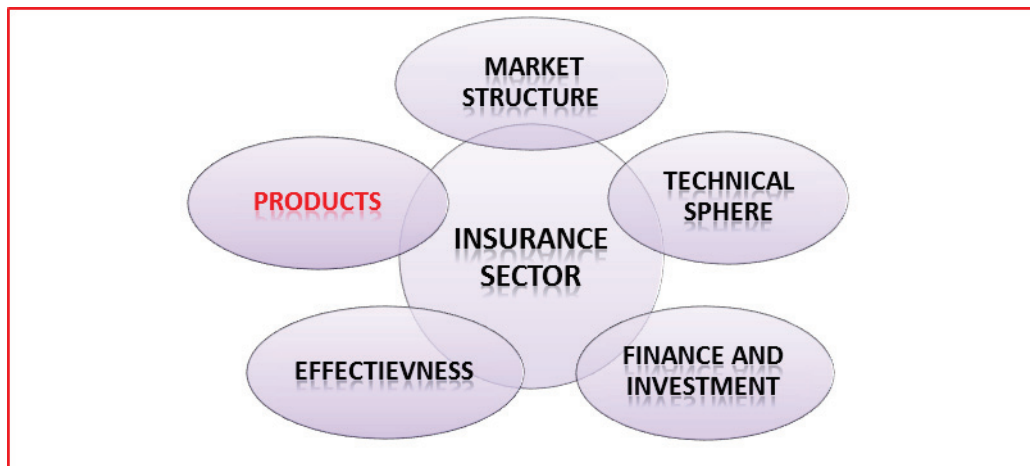
Figure 1. Groups of features used in the study
Source: Authors' own material

The paper is aimed at the demonstration of the lack of insurance product innovation. That is why we do not present a detailed description of all groups. The market structure group includes diagnostic features like the number of insurance entities, speed of changes within this number, the market share of the biggest insurers, market concentration, the number of people employed by insurers or the presence of foreign insurers in the market. The technical sphere refers to the insurance operations. The group includes features like the value of gross written premium, changes in such a level, retention ratio, share of European countries in total gross written premium, divided into non-life and life insurance as well as the reinsurance ratio. The finance and investment group is represented by features like the value of total insurance investments in the European countries, relation between investment and gross written premium or changes in investment level between 1997 and 2010 (separate for non-life and life insurers). The effectiveness represents features that could be used to assess the development of the insurance sector from the macro perspective. In that group we have included features like the share of gross written premium in GDP, relation between insurers investment to GDP, gross written premium per capita separately for nonlife and life insurance. The most important from the perspective of the main aim of the paper is group called PRODUCT. There are fifteen features included in it. The features are listed in the table below:

Table 1. The diagnostic features included into PRODUCT group.

Symbol	Name of the feature
E1	Motor insurance gross written premium per capita
E2	Growth of motor insurance premium
E3	Share of motor insurance premium in total non-life insurance premium
E4	Health insurance premium per capita
E5	Growth in health insurance premium

Symbol	Name of the feature
E6	Share of health insurance premium in total nonlife insurance premium
E7	Property insurance per capita
E8	Growth of property insurance
E9	Share of property insurance premium in total nonlife insurance premium
E10	Liability insurance premium per capita
E11	Growth in liability insurance premium
E12	Share of liability insurance premium in total nonlife insurance premium
E13	Marine, air and cargo insurance premium per capita
E14	Growth in marine, air and cargo insurance premium
E15	Share of marine, air and cargo insurance premium in total nonlife insurance premium

Source: Authors' own material.

Results – lack of product innovation within the insurance sector

The assessment of the sector development directions was made in the selected years of the analysed period. The benchmark was set for comparison. In our case the benchmark based on algorithms was set within the group of experts and presented by well-known statisticians (Z. Hellwig), separately for individual kinds of diagnostic features. In the case of stimulants the benchmark was calculated as a diagnostic feature of the maximum value in the analysed period increased by a standard deviation for the whole time series. In the case of destimulants the benchmark value is 0 or minimum value decreased by a standard deviation, depending on which of the two values is higher. For nominants, the benchmark value was set as an average value increased by a standard deviation or median depending on the character of the feature and the number of available observations. In order to maintain the clarity of the presentation the radar charts were used. The chart axes are the analysed groups (in the case of sector analysis). Thus, A stands for market structure; B for technical sphere; C for finance and investment, D effectiveness and E - products. The results of calculation for the measure of differentiation of levels d* and structure similarity µ* are presented in the charts below respectively. The results for Poland and chosen EU countries are presented in the graphs below.
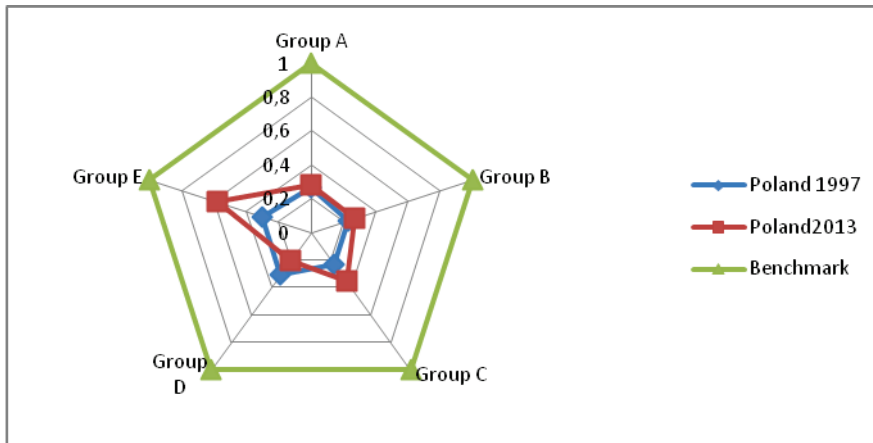
Figure 2. Measure of structure similarity μ* for Poland
Source: Authors' own calculations
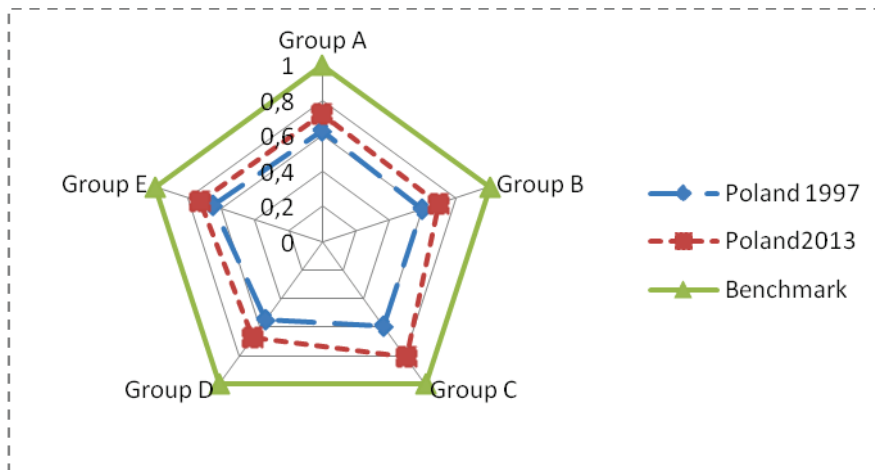
Figure 3. Measure of differentiation of levels d* for Poland
Source: Authors' own calculations
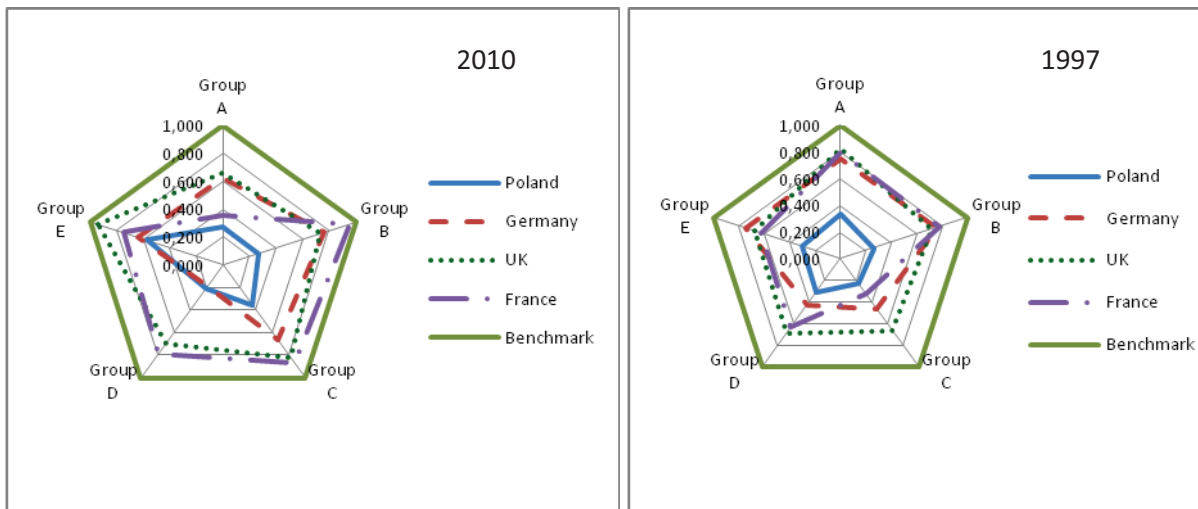
Figure 4. Measure of structure similarity μ* for Poland and chosen EU countries in 1997 and 2010
Source: Authors' own calculations
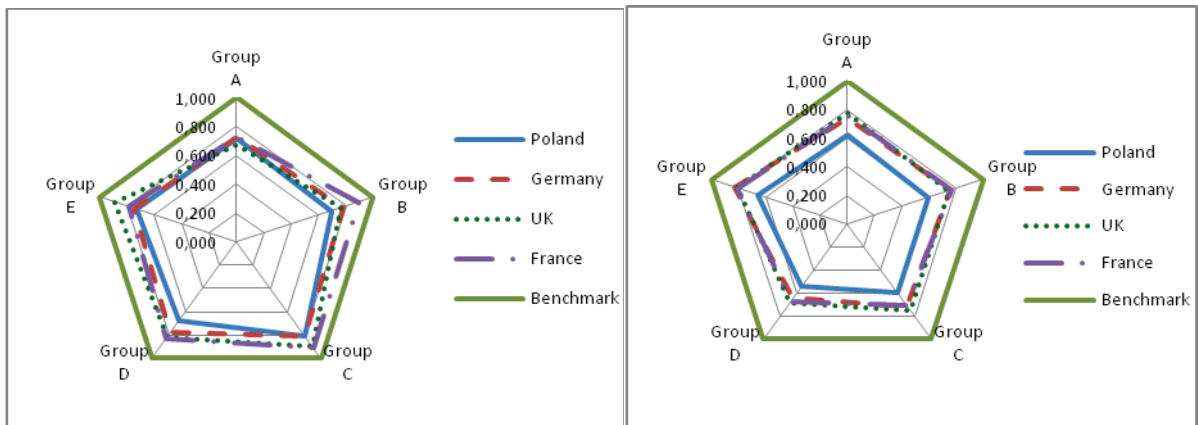
Figure 5. Measure of differentiation of levels d* for Poland and EU chosen countries in 1997 and 2010
Source: Authors' own calculations

For the clarity of the presentation we have also decided to present the value of the used measures in the tables below. The values of the measures refer to 1997 and 2010 respectively.

Table. 2. Measure of structure similarity μ* for Poland

	Group A	Group B	Group C	Group D	Group E
Poland 1997	0.2629	0.2293	0.234	0.3054	0.3006
Poland 2010	0.2773	0.2662	0.359	0.2050	0.5790
Benchmark	1	1	1	1	1

Source: Author's own calculations.

Table. 3. Measure of differentiation of levels d* for Poland

	Group A	Group B	Group C	Group D	Group E
Poland 1997	0.6270	0.5972	0.5962	0.5429	0.6564
Poland 2010	0.7209	0.693	0.8116	0.6732	0.7309
Benchmark	1	1	1	1	1

Source: Author's own calculations.

Table. 4. Measure of structure similarity µ* for chosen EU countries

2010	Group A	Group B	Group C	Group D	Group E
Poland	0.277	0.266	0.359	0.205	0.579
Germany	0.622	0.765	0.663	0.189	0.640
UK	0.658	0.734	0.829	0.701	0.946
France	0.361	0.956	0.870	0.784	0.753
1997	Group A	Group B	Group C	Group D	Group E
Poland	0.335	0.263	0.229	0.305	0.301
Germany	0.747	0.757	0.465	0.428	0.747
UK	0.830	0.720	0.662	0.692	0.677
France	0.793	0.782	0.323	0.631	0.621
Benchmark	**1**	**1**	**1**	**1**	**1**

Source: Author's own calculations.

Table. 5. Measure of differentiation of levels d* for chosen EU countries.

2010	Group A	Group B	Group C	Group D	Group E
Poland	0.721	0.693	0.812	0.673	0.731
Germany	0.730	0.781	0.805	0.779	0.751
UK	0.679	0.765	0.893	0.819	0.887
France	0.724	0.893	0.909	0.832	0.785
1997	Group A	Group B	Group C	Group D	Group E
Poland	0.627	0.597	0.596	0.543	0.656
Germany	0.738	0.758	0.715	0.645	0.828
UK	0.774	0.750	0.753	0.680	0.809
France	0.756	0.764	0.703	0.668	0.808
Benchmark	**1**	**1**	**1**	**1**	**1**

Source: Author's own calculations.

The analysis of the aforementioned results shows the lack of significant changes in similarities of both structure and price level differentiation. In Poland in the analysed period, within the structure similarities the most important change occurred in group E, i.e. products. However, it is not possible to speak about considerable product innovations which can change the structure in the product group. A simultaneous analysis of the same measure in selected European countries allows for the conclusion that the Polish insurance market has adjusted to such developed markets as the German of French market. Generally, in the selected European countries there were no changes in structure similarity or price level differentiation similarity. The British market is an exception; in group E it has most closely approached the model concerning the structure similarity and similarity of price level differentiation. The present economic situation and the turbulence on financial markets required more radical changes from insurance entities, which are composition elements of these markets.

The lack of significant changes in the structure and the sphere of products allows for the conclusion about a weak innovativeness of the insurance sector, especially in the sphere of products. This gave rise to considerations and search for the methods or tools which could be used in the process of motivation and support the pursuit of innovative activities. It seems that in the insurance sector the lack of innovativeness results from the fact that the persons responsible for the development of the sector have not noticed yet the significance of the problem due for example to the growing importance of the so-called new risks. As indicated before, the available statistical data are not sufficient enough to evaluate and quantify this risk. That is why, in the following section we will discuss the characteristic features of the so-called new risks and then we will present a method to support product innovations of insurance companies.

New risks faced by the insurance market

The research results presented above indicate a low level of innovativeness of the insurance sector, especially in the product aspect. Slight changes in the structure similarity of analysed features as well as similarity of price level differentiation in the examined period occurred practically in all the considered insurance markets. It is not the domain of the Polish market, which is perceived as a developing market. It may be stated that in the period of the last several dozen years the Polish market has approached developed markets such as the German, French or British market. The civilisation growth and ongoing globalisation make the so-called new risks increasingly crucial. The notion means changes in the surrounding world in the area of new hazards threatening the individual existence. Risk is a universal notion, one of the most popular and most frequently used in all sort of discussions, including scientific analyses, numerous practical applications as well as in a colloquial speech. A great popularity and the aforementioned broad application of this notion results from the fact that risk belongs to the notions of a high level of complexity, which as a consequence is not without an impact on its information capacity and is reflected in the semantic area ascribed to this popular notion. It is possible to make a bold hypothesis that the popularity of the notion

reflects a complex and heterogeneous nature of risk, which consequently allows for a broad application of the notion of risk in different aspects and gives an analytic opportunity in different contexts. Simultaneously, it should be stated explicitly that the specificity of the notion of risk and its different perceptions require a few explanatory remarks. Omitting these remarks or ignoring them in further deliberations may lead to misunderstanding and consequently to considerable logical or even substantive mistakes.

One of the basic features of risk undisputed by a decisive majority of researchers is the fact that risk is an objective category. As already remarked, it is a feature commonly recognised by the researchers working on risk. However, when entering complicated procedures connected with the quantification (measurement, evaluation), some begin to forget the objective nature of risk. It should be clearly emphasized that we begin to differentiate objects in relation to the considered risk at the moment we enter the sphere of risk realisation, which is understood as a course of events whose characteristic feature is that they are random events causing losses or profits. The results of risk realisation depend on causative factors as well as risk factors, which can be divided into subjective and non-subjective, affecting the so-called intensity and probability of risk realisation. Different entities may be found in different situations or states with different probability (pursuit of different scenarios). As a result, there are different probabilities of realisation of the same risk with different intensity. Thus, the major discriminatory factors, i.e. factors allowing for the distinguishing of entities in relation to a given risk in the area of risk realisation, are such features as risk realisation probability (different for individual entities) and risk realisation intensity (different for individual entities). In this way we emphasize risk objectivity as well as the fact that risk is a process not a state. As a consequence, the deliberations on risk include such categories as the object of risk, risk realisation, risk realisation probability, risk realisation intensity, risk realisation effects, which occur as elements phases of the process, and differences as already remarked occur in the area of risk realisation. With many factors affecting risk realisation, the probability and intensity of risk realisation depend on these factors and constitute essential characteristics allowing for the differentiation of entities with regard to a given risk. As a result, when speaking about risk, we should take into account the diagram presented in Figure 6. It presents the process of risk with its composition elements. The diagram, together with the characteristics of the sphere of realisation, is a starting point for the procedures of quantification (measurement) of risk. At the same time, it is worth noting that the three elements shown in the diagram are often treated jointly as risk in the deliberations on the problem.

The observation of events occurring in the world, analysing the literature and research conducted by prestigious university or business institutions, allows for the distinguishing of three groups of risk with a significant growth in the degree of their realisation. Due to the fact that these risks are relatively new, it is difficult to make use of traditional methods of their quantification applying for example the probability of realisation as a basic risk measure. And due to the lack of sufficient statistical data concerning the past, it is difficult or

really impossible to assess the intensity of risk realisation in such cases as digital risk, cascading catastrophe risk or nanotechnology risk[4].
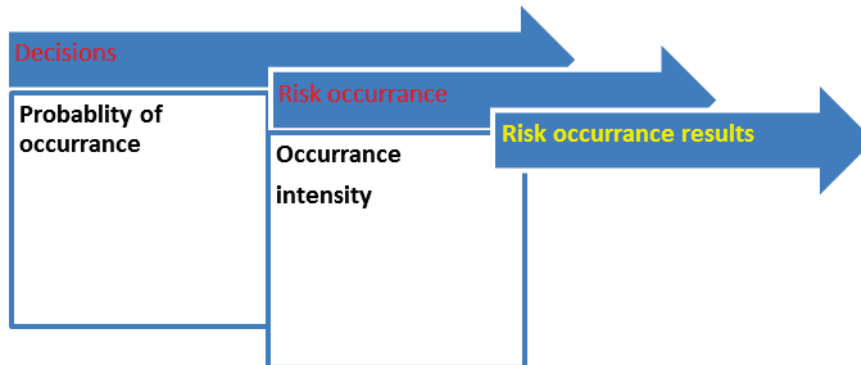
Figure 6. Risk as a process
Source: Authors' own material.

The digital risk is not understood as hacking attacks and computer assisted frauds, but the centralisation of data in connection with the change of likes and dislikes of consumers and the common application of devices not possessing their own hard disks. The risk of cascading catastrophes consists in enormous accumulation of damage caused by a catastrophic event. An example to quote may be an earthquake in Japan and the Fukushima nuclear power plant catastrophe related to it. The area of our interest includes the risk connected with the application of highly advanced production technologies which are well exemplified by the development of nanotechnology. The following section describes the issue in detail.

There are many definitions of nanotechnology. One of the most popular and useful from the point of view of insurance is the definition presented by K.E. Drexler. He defines nanotechnology as "molecular production."[5] The Drexler definition for the first time points to the possibility of implementing production through the use of nanotechnology. And the very name of nanotechnology was first used by a Japanese scientist Nori Tanguchi. He defined nanotechnology as a production technology allowing for extraordinary accuracy of 1nm and exceptionally small sizes[6]. The nanotechnology definition was then extended by the American NASA claiming that nanotechnology is also a research of new phenomena and physical, chemical, biological and mechanical properties on the nanoscale level (1-100nm)[7]. The innovativeness of nanotechnological solutions was emphasized by the United States'

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[4] Research published by Oxford University scientists (see: http://www.risk.jbs.cam.ac.uk/) or Lloyd's of London reports(see: *Managing digital risk,* Lloyd's of London, http://www.lloyds.com/news-and-insight/risk-insight/reports/digital/managing-digital-risk) accessible as of 2014-03-13.

[5] K. Eric Drexler, Engines of Creation, *The Coming Era of Nanotechnology*, Nowy Jork: Anchor Books, Doubleday 1986, ISBN 0-385-19973-2

[6] N. Taniguchi, *On the Basic Concept of 'Nano-Technology'*, Proc. Intl. Conf. Prod. Eng. Tokyo, Part II, Japan Society of Precision Engineering, 1974.

[7] http://www.nasa.gov/offices/oce/appel/ask-academy/issues/ask-oce/AO_1-8_F_small.html, accessible as of 2014-03-13.

National Nanotechnology Initiative which defined the notion as the perception and control of the matter on the scale from 1 to 100 nanometres, where exceptional phenomena allow for novelty applications. Nanotechnology creates unprecedented possibilities for the civilisation progress. In future, it may affect many areas of our activity, generating enormous threat at the same time. According to researchers and persons working on the issue, the most important risks connected with the development of nanotechnology should include[8]:

1. **Real Risk: Nanopollutants -** nanopollutants are nanoparticles small enough to enter your lungs or to be absorbed by your skin. Nanopollutants can be natural or man-made. Nanoparticles are used in some of the products found on shelves today, like anti-aging cosmetics and sunscreen. The highest risk is to the workers in nanotechnology research and manufacturing processes.

2. **Potential Risk: Privacy Invasion -** virtually undetectable surveillance devices could dramatically increase spying on governments, corporations and private citizens.

3. **Potential Risk: Economic Upheaval (in 5 to 10 years) - m**olecular manufacturing is the assembly of products one molecule at a time. It could make the same products you see today, but far more precisely and at a very low cost. It is unclear whether this would bring boom or bust to the global economy.

4. **Potential Risk: Nanotech weapons (in 10 to 20 years) -** Untraceable weapons made with nanotechnology could be smaller than an insect with the intelligence of a supercomputer. Possible nano and bio technology arms race.

5. **Far-Fetched Risk: Gray Goo (in more than 30 years) -** Free range, self-replicating robots that consume all living matter. However unlikely, experts say this scenario is theoretically possible, but not for some time.

For the time being, it is most crucial to apply nanotechnology in the process of production, especially from the point of view of risk. The application of nanotechnology in the process of production poses a potential threat on three basic planes, i.e. at the stage of the acquisition of modified raw materials, the production proper as well as the use and utilisation of final products by consumers (see Figure 7).

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[8] http://www.futureforall.org/nanotechnology/risks.htm, accesible as of 2014-03-13.
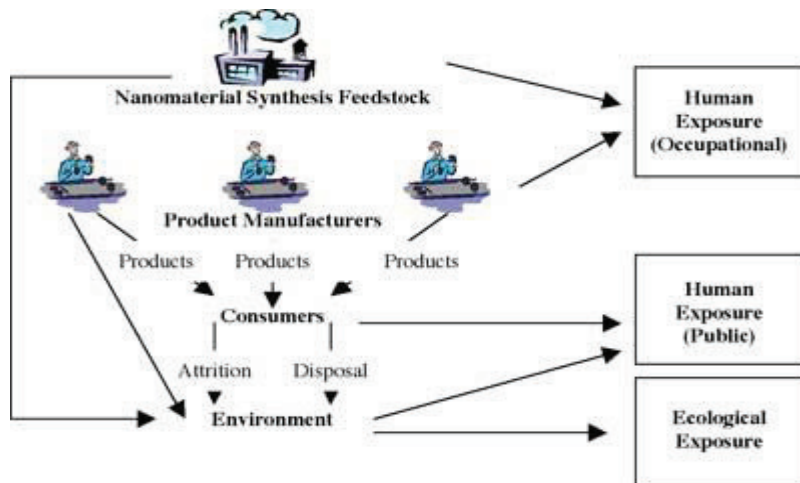
Figure 7. Potential for release of and exposure to nanoscale substances

Source: Joyce S. Tsuji: "Research Strategies for Safety Evaluation of Nanomaterials, Part IV: Risk Assessment of Nanoparticles", accessible as of 2014-03-13.

Companies applying nanotechnology are becoming innovative entities, but innovation creates additional threat for both the entity and the community. The environmental threat is also important. Therefore, insurance companies should offer insurance against the effects of risk realisation connected with nanotechnology. This task is extremely difficult because insurance companies do not possess adequate historical data in relation to the frequency of occurrence of unfavourable phenomena as well as their intensity. Thus, traditional insurance risk modelling, with the application of historical data, is difficult. Due to this, in the following section of the article we present the application of the management accounting method which makes use of the future data.

LEARNING CURVES IN THE IDENTIFICATION AND MEASUREMENT OF COSTS CONNECTED WITH THE FUTURE OF PRODUCTS "WITHOUT HISTORY" AND THEIR POTENTIAL INSURANCE PROTECTION

The analysis of insurance risk in relation to an insurance product "without history" (PBH) is a big conceptual challenge and requires the creation, practically from scratch, of model methodology. This methodology will undoubtedly require a systemic approach and focus on:

(a) the condition of the company in which such a PBH is launched and the related technological risks,

(b) PBH life cycle in which cost and benefit forecast is particularly difficult due to:

- the lack of market experience (supply/demand),
- high costs of production resulting possibly from the product novelty and the application of highly specialised technology,
- the need to evaluate the corporate financial condition in relation to the source of financing of this kind of production in order to determine the value of cost of

the acquisition of own and third party capitals and to examine the company's ability to cope with them,

(c) the readiness of the target market segment (customers) to purchase the innovative product (PBH) and a possibility of rejecting the product by the market, which means "sunk costs" and may lead to serious financial problems,

(d) the examination of the whole assortment structure of company's products which could become a safety buffer for the company to continue business activity in the case of the BPH market rejection,

(e) environmental and social aspects and consequences of PBH production and sales, which means the need to get familiar with the expert opinion on the usefulness of BPH in the business development of the company introducing it as well as in the area of effects and role in the civilisation and business development of the region, country and the world.

This sort of research is recommendable due to the threat of **costs sunk in PBH, a possibility** of serious financial trouble, and as a consequence the bankruptcy of the company. It is particularly important in the situation in which an insurance company would undertake the **insurance protection of the financial result of the PBH production activity**.

However, if the insurance company was to render a third party liability insurance coverage (social, health or environmental) for the damage resulting from PBH use, the problems mentioned in a-c become less important. The priority should be given to the environmental and social plane as well as the need for expert (also engineering) evaluations of PBH technological safety and the determination of the range of possible threats. Presumably, it would be connected to a large extent with the description similar to the information about a medicine: what purpose it serves, how and in which circumstances it should be used, what the threat is for the individual, the closest environment, the region etc.) and in which period, what preventive actions should be taken against the negative aftereffects, whether such activities are technologically possible or whether the environment affected by the negative aftereffects is able to undertake such activities, whether it is in the possession of adequate funds.

It may be concluded from the aforementioned ideas that: (1) **sustainable development, (2) PBH innovative technologies**, (3) **the need to introduce innovative insurance protection into the insurance sphere** (which may be conducted in the PBH area) jointly pose big specialist requirements to insurance companies in the area of PBH related risk determination. These competences include the knowledge of not only nanotechnology (PBH) and the clairvoyance in relation to its potential effects. An ability to apply tools (concepts) of modelling of its financial results is also important. Eventually, an insurance company pays a monetary compensation or benefit and the point is that the premium as well as the insurance sum connected with such an innovative coverage should be properly calculated, i.e. in such a

way that the insurance company could cover losses resulting from the realisation of the "nanotechnological risk."

In this place, the authors do not present a complex model of evaluation of risk connected with the PBH insurance protection. As a matter of fact, it is only to be created. However, due to the fact that we are witnessing the development of nanotechnology and we should notice both positive and negative aspects of such products as well as unknown risk factors related to it, which may become a potential insurance risk, in the present text they conceptually verify the application usefulness, in the course of PBH insurance risk evaluation, of one of many management accounting concepts.

This verification is undertaken in view of the conviction that irrespective of the way insurance companies assess insurance risk connected with nanotechnologies, it seems useful to:

1. **analyse the concept of the *learning curve* and verify its parameters in the condition of highly advanced technologies,**
2. **indicate the possibility of the *learning curve* application as a tool supporting the evaluation of the insurance risk.**

Analysis of the *learning curve* concept and verification of its parameters in the conditions of highly advanced technologies

Learning curve is a function which, in the primary classical meaning, measures the reduction in outlays (C) per effect unit (for example of a product) (P) together with the growth – in the process in which these effects (P) are created – in the total volume of repetitive activity (QP). In the *learning curve* it is assumed that the decline in outlays (C) **is a result of the process of learning and acquisition of experience: knowledge, skills and other competences allowing for the achievement of repetitive effects (P) with lower outlays.**

Practically, there are two **learning curve models:**[9]
(1) cumulative average learning time model,
(2) incremental unit time learning model.

For example, the cumulative average learning time model **assumes that an average cumulative time per product unit** (e.g. 56.17 time units (TU) per each of six product units) **declines by a constant percentage** (e.g. 20%, with 80% inclination of the learning curve) **every time when the volume of the product doubles** (e.g. with the production dimension at the level of 12 production units (PU), an average cumulative time per each of these twelve

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[9] Horngren Ch.T., Datar S.M., Foster G., *Cost Accounting. A Managerial Emphasis*, Twelfth Edition, Pearson. Prentice Hall, 2006, pp. 349-352.

TUs amounts to 44.93 TUs, i.e. 80% of 56.17 TUs). It may be said then that as a result of learning, an average cumulative time per product unit declines by 20%.

The model of cumulative average learning time may be presented in the form of the following function:

$$y = aX^b$$

where:

y – cumulative average time per unit

X– cumulative number of manufactured products

a – unit time of first product manufacturing

b – ln (coefficient of learning time effects)/ ln 2

This concept is broadly applied in management accounting, in which there are important decisions for example in the area of planned remuneration costs in connection with the growth of production volume. (For example[10], with 80% of learning curve, parameter b will have the value: b=ln 0,8/ln 2 = - 0,2231/0,6931= - 0,3219. And if the volume of output amounts to 3 units and the unit manufacturing time of the first product amounted to 100 man-hours, the cumulative average time with the volume of output of 3 units accounts for 70.21 man-hours (i.e. y=100 x $3^{-0,3219}$), which means that the cumulative production time of these three units amounts to 210.63 man-hours (i.e. 3 x 70.21). Knowing the cost of one man-hour, one can forecast the outlays on work directly related to production.

According to Horngren, Datar, Foster[11], the learning curve is more and more frequently mentioned also in the cost analysis of processes taking part in value creation, i.e. in distribution, marketing or rendering services. In these processes there are no products in the classical sense and this is probably why these broader applications of the *learning curve* are described by them as the *experience curve*. Such *experience curves* are usually examined in corporate activities included in the value chain (e.g. marketing or sales) and they present a decline in the unit cost of this product identified in this activity, i.e. (P), (in the terminology of activity cost accounting this activity product may be called an *activity carrier*) in the context of volume growth of these activities to be measured with the number of implemented activity carriers.

From the conceptual perspective, on the basis of the aforementioned observations made by Horngren, Datar and Foster, there are no contraindications to thinking in the *learning curve* categories in relation to the costs of practically every process, even the one in which there are no classically perceived products. It is important to observe that the experiences translate into the decline in costs, as a result of which there is a decline in the unit cost of the object in which the experiences have been consumed.

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[10] See: Horngren, Datar, Foster, op.cit., p. 350.
[11] Op.cit., p. 349.

If assumed that in the evaluation of insurance risk connected with a PBH nanotechnological product it will be important (despite the lack of market experience) to analyse the business cycle of such a product, it will be essential:

(a) to estimate probable volume of sales in every phase of the life cycle of such a product, and consequently the value of incomes, which, expectedly, may be subject to changes over time – demand fluctuations, competition or substitutes,

(b) to forecast manufacturing and other costs, also financial appropriate for individual life phases of this product. It seems that one should not resign from the considering, within the PBH product life cycle, the decline in costs achieved thanks to the implementation of solutions resulting from the experience gained over a longer and longer period of PBH production. **It may be a significant value in the whole economic account of this kind of production, which may be of a particular importance in the evaluation of insurance risk connected with the financial results of the PBH manufacturing company.** The application of learning effects requires a prior diagnosis in view of which it should be found out if a given nanotechnological company is really, in the economic sense, a learning organisation. Because only in this case is the application of effects of the decline in costs determined by the learning curve or experience curve could be justified. It is not connected with the application of more and more advanced technological knowledge. In a learning organisation people are searching all the time for new possibilities of achieving the desired effects, they create new patterns of non-stereotypical thinking, develop their team work and learn constantly. A learning organisation is experienced in the implementation of creative tasks, acquisition and transferring of knowledge, and modification of their behaviour in reaction to new knowledge and experience. The concept of learning is closely connected with the implementation of the corporate innovative strategy[12].

If the diagnosis mentioned above brings a positive reply, it is worth noting that in the analysis of future costs of a nanotechnological product in the course of its whole life cycle *learning curves* and *experience curves* should be considered. They are connected with outlays and effects in a few **processes**: (1) marketing, (2) production, (3) sales, (4) PBH aftersales service (warranty, guarantee) **and – in a given company – they are characteristic of these**

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[12] However, at present according to management experts there are no clear principles of how to manage learning organisations, as well as the descriptions of methods and techniques related with it. There are no measuring tools to assess the organisational level of competence and level of learning, and these tools are indispensable to assess what practical effects are achieved by corporate management within the concept of learning organisation. See more: G. Gierszewska, R. Romanowska, *Analiza strategiczna przedsiębiorstwa (Corporate strategic analysis)*, PWE Warsaw 2003, pp. 140-149, pp. 140-149.

processes, and may be really unique in in the PBH production process. Each of these processes has its own specificity and requires different classification of outlays (C), as well as a different definition of repetitive effects (P). It should be underlined that the efficiency of people involved in a given process depends on personal competences but also sufficiency and quality of resources provided for them to use.

The discussion presented below includes modifications and limitations and deals with an opportunity to use the *learning curve* in forecasting costs of the manufacturing process conducted in the PBH technology. Assuming that an insurance company in the developed model of evaluation of insurance risk connected with PBH considers the concept of the *learning curve* in the assessment of credibility of cost forecast of a PBH product manufacturing in the course of its entire life cycle, the explanation of this concept has a universal character. It means that in this form it may be used in the company itself as well as in the insurance company verifying the source documents examined in the process of evaluation of insurance risk and submitted by a potential customer (company).

The priority in the concept of the learning curve is given to the **understanding of experience outlays and effects**.

In the classical approach, in the *learning curve* outlays (C) are measured by man-hours involved directly in the effect (P). It is assumed that the experience acquired by people in the manufacturing process, similarly to exercised skills, may contribute to people's higher efficiency while performing the next (the same as the previous one) effect unit (P). The skill perceived in this way may be measured by the time of performance of a given (repetitive) effect (P). The learning curve presents – in this primary sense – the relation between: **(1)** the effectiveness of people involved in a given process, **(2)** productivity of this process as well as (3) decline in unit costs of effect creation (P) of this process.

In the analysis made in this text the problem of outlays is important because at present, in view of robotisation of manufacturing processes, the cost of purely productive (in a sense manual) human labour time plays a lower and lower role or is an insignificant driver of costs of nanotechnological products (PBH). The most important are the costs of: (a) used material assets, (b) amortization of nanotechnological know-how value and technical appliances used in this production, (c) costs (most probably fixed) connected with monitoring of production quality and maintaining production capacity at the highest technological level.

In view of the above, there is a well-grounded question to be asked: Do the observations disqualify the application of the learning curve in relation to highly advanced manufacturing technologies? In the first impression – yes. However, let us note that:

1. if a nanotechnological company is a learning organisation, there will be a kind of standard consisting in a permanent desire to optimise costs, which requires a permanent cost monitoring and improvement of processes, in particular those with a large share of fixed costs,

2. in a nanotechnological company, for the re-engineering (optimising manufacturing costs) of nanotechnological processes, the work and learning of people employed outside the process of direct PBH production is a key issue.

As a result, for a nanotechnological company it seems well justified to **verify the understanding and measuring outlays** important for the determination of the *learning curve*. It is here where learning of a man not working manually in the manufacturing of the PBH product translates into the costs of manufacturing process, in particular these costs which in this process may have a character of fixed costs. The reduction in these costs will certainly cause a decline in unit full costs of PBH manufacturing, even with the same (not increased) volumes of production. This impact, i.e. **the decline in fixed costs in absolute values will take effect abruptly,** i.e. after the introduction – as an effect of experiences and observations gained by people – of reengineering changes in the manufacturing process, improving the activity efficiency and effectiveness of manufacturing process and appliances used in it. This is the **first** issue. **Secondly**, in highly advanced technologically (really futuristic) nanotechnological manufacturing processes, to determine the *learning curve* in the manufacturing process of nanotechnological PBH, it is necessary to choose an appropriate cost driver thanks to which outlays can be measured.

As stated above, in the case of nanotechnological production which does not involve people in the manufacturing process (not at all in direct manufacturing or to a slight extent), the function of the cost driver should be performed by the measures reflecting in the best possible way the PBH production cycle or – even better – both *production cycle* and a notionally broader *operational cycle.* It may be, for example, the duration of the production or/and operational cycle expressed in days. **The duration of these cycles and the observed tendencies to make them shorter may reflect the gained experience, the ability to use it in the organisation of the production cycle as well as in the pre- and post-production management (also in the financial sense).**

It should be noted that – actually irrespective of whether we have to do with a company producing PBH nanotechnologically or another company – *the duration of the production cycle* – technologically appropriate – of the unit measure of a nanotechnological product does not depend on the volume of production. It is strongly dependent on the organisation of the production process. There are two components of the production cycle time measured in this way, only one of which is susceptible to changes resulting from experience. The use of organisational experience of people thanks to which the duration of the production process may be shortened is limited to the possibility of affecting the duration of particular activities in the production cycle different than those strictly technological, pursued in compliance with

the manufacturing technology[13]. In a given technology, the duration of these activities cannot be affected, unless there is a change in the prescription or manufacturing process in a physical or chemical sense. The time that can be affected is connected with performing a logistic activity.

The time absorbed by logistics of the production cycle on the one hand lengthens the production cycle, and on the other consumes the company's assets; in short – it is costly and it makes manufacturing unit costs higher. In this organisation fragment of the production cycle, which is "soft," i.e. susceptible to changes one may find potential opportunities to make use of the acquired experience. The organisation of such production cycle fragments determines to a large extent fixed costs, as it shortens the production cycle duration and at the same time optimises the work of fixed assets involved in this production. It may also lead to the elimination of production defects and production of low quality, which is not indifferent for the production cycle duration, the volume of production implemented and costs related with it. Thus, as it may seem, to a large extent primarily ***organising, re-engineering and improvement of the organisation of PBH manufacturing process logistics*** causing decreases in the level of fixed costs accompanying production (nanotechnological or different)– may strongly affect the pace of decline in unit manufacturing costs.

In the case of companies applying highly advanced technologies it cannot be excluded that experience may be acquired not only by people, which – in the context of the learning curve – gives rise to the need for the verification of the term "experience." Highly advanced technologies stimulate imagination and lead to philosophical questions: Is experience a human specific attribute or can nanotechnology (although artificial), be intelligent enough to gain **experience** and make correction of the production process in the course of manufacturing of a nanotechnological product? It sounds futuristic but not unrealistic. Importantly, a fast growing area of the so-called machine learning (making use of the achievement in the area of artificial intelligence, robotics, information technology and statistics) in nanotechnology may have a comprehensive application. In such a case machine learning is a process:

- consisting in the creation of an automatic system which could improve itself by means of the collected **experience** (in the form of acquired data) and the acquisition, through algorithms of data analysis – from the human perspective, new knowledge and skills,
- perceived as a change (improvement) – thanks to artificial intelligence – in selection of important choices of algorithms of machine operation, leading to the improvement and development of its own steering system.

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[13] The application of knowledge of new technologies is not considered here, as this text is concerned with the situation in which nanotechnology has already been fixed and the decision about its commercial application have been made. From the company perspective, there is a need for risk management of this production through the purchase of an adequate insurance policy, and from the perspective of an insurance company, there is a need for the evaluation of such a new insurance risk which has not been analysed so far.

This process may improve and shorten the time of an inaccessible for a human being, technological fragment of the production cycle period, which is a goal of machine learning.

All in all, in a technologically advanced production process the ***learning curve*** seems exceptionally complex, in a sense **double-track**, because outlay reduction may be achieved here thanks to **experience** (learning), which in the manufacturing processes, making use of robotics and artificial intelligence, may be acquired at the same time by humans and machines. Theoretically, a *joint learning curve* could be considered, or two separate curves: a *human learning curve* and a *machine learning curve*. Such an analysis seems intriguing. However, in this place only scientific interest is being communicated.

The problem is complex, and in practice if the aforementioned observations were to be applied in relation to a nanotechnological company, they should be well matched with the specificity of the organisation and technology used in the company. The key issue here is the awareness of the appearance in the production cycle period of some fragments of this period which are susceptible to changes introduced due to: (a) the experience of people who actually are not involved directly in production as well as (b) learning machines used in this process. The joint learning curve would express the pace of shortening the *production cycle unit period*, which could be interpreted as outlay C, with the growth of the parameter which should be properly set now to correspond to the QP size, according to the classical perception of the learning curve.

The problem which needs to be discussed at the moment is **parameter QP**. Theoretically, it could be: (a) the growth in in the volume of PBH production for the *machine learning curve* and (b) lengthening of the period of this kind of production activity for the *human learning curve*. Symbolically, it could be presented as follows:
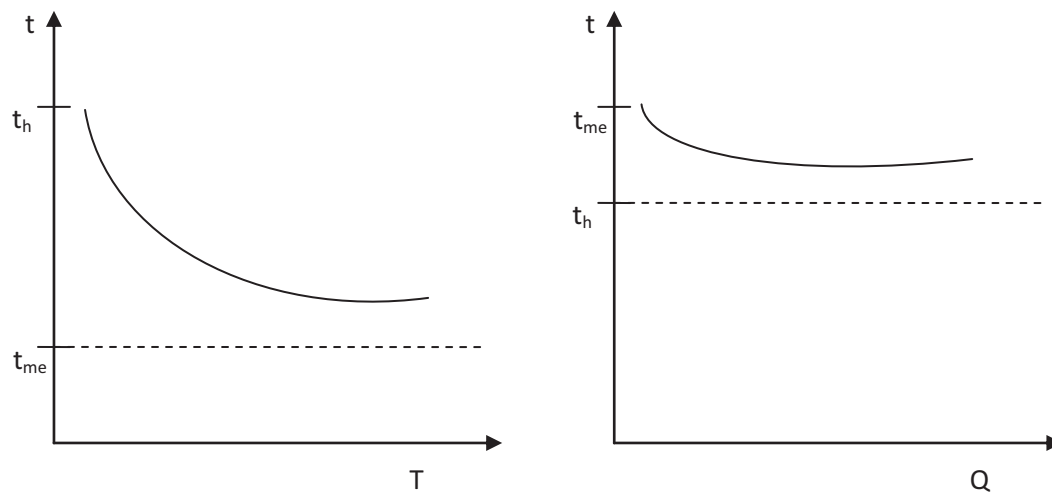
(a) human learning curve   (b) machine learning curve

T – product business life period (without the design and liquidation phases)
t – production cycle unit period ($t_{he} + t_{me}$)
t_{he} – fragment of PBH production cycle unit period susceptible to human experience
t_{me} – fragment of PBH production cycle unit period susceptible to learning machines experience
Q – PBH production volume.

Figure 8. Human and machine learning curves
Source: Own material

Learning curve as a tool supporting the evaluation of insurance risk

In practice learning curves, which are important in forecasting costs, are determined on the basis of retrospective data. In the situation which the aforementioned considerations refer to, i.e. in the case of PBH producing companies, which the authors tried to emphasize referring to the example of nanotechnology, the retrospective information is simply unavailable. (For the sake of clarity, it should be underlined that what is meant here is the situation in which the PBH technology has been determined and the insurance company makes a decision about the insurance coverage of expected company's results from the PBH production or company's liability on account of potential consequences (effects) of the PBH production process or the use of finished PBH). **In view of the above, there is another well justified question: Should the lack of retrospective data needed to mark out a learning curve in a PBH producing company mean a definite rejection of this concept, even if it was to be used only as one of many tools supporting the evaluation of insurance risk?**

Looking for an argument for the usefulness of the concept of the *learning curve* in the evaluation of insurance risk, it is worth noting that for an insurance company it could be important to know whether or not the retrospectively determined *learning curves* appear in other processes, not only and exclusively those connected with the PBH production. Such

information could be a signal to show the insurance company that it has to do with a learning organisation, which could allow for the general identification of company susceptibility to innovation in the area of management of activities, including logistics, which appear – although they may be different than in a pre-production phase – also in PBH production and are crucial, as already indicated before, for the learning curve in the process of production using highly advanced technologies.

The fact of the lack of unavailability of the gradient of a retrospectively determined learning curve in the process of PBH production does not eliminate a possibility of thinking in the categories connected with a potential learning curve in this process. One can try to model such a curve considering: learning curves known from other processes, remarks made above in relation to the very concept of a learning curve in processes applying highly advanced technologies, the structure of costs of production, ascribed to the detailed production activities, divided into variable and fixed costs, the structure of managerial competences of the management staff as well as the quality of intellectual capital of the staff responsible in particular for the effectiveness of the PBH production process. The modelling will not be simple but the proposal in this area would certainly be a great contribution to science in the area of cost management of such a process and the management of insurance risk connected with such a process.

CONCLUSIONS

In conclusion, there are important issues are to be considered when modelling the evaluation of insurance risk connected with the high technology production (e.g. nanotechnology), for example:

1. the necessity for the acquisition of technical and environmental expert reports, safety certificates and other documents confirming the limitation of technological and environmental risk factors connected with a PBH product,
2. the need for a number of quality analyses, in relation to the company which is a potential customer, thanks to which the insurance company may obtain its opinion on the following questions:
   - Is the company really a socially responsible organisation and not the one that only declares this responsibility and whether it behaves ethically with regard to its customers and stakeholders?
   - To what degree does the corporate financial condition guarantee the continuity of operation even in the case of serious technological problems and difficult social consequences requiring large financial outlays to overcome them? Does the company apply other risk management instruments (including financial risk) apart from insurance?
   - Does the company possess any features of a learning organisation? What is the experience curve in this organisation in relation to other processes and activities, not the production process?

- Is it possible to determine a probable *human learning curve* for the production process based on the extrapolating of experience curves observed retrospectively in this company with reference to a pre-production logistic process?
- What is the degree of technicisation or robotisation of production? Are there any technological solutions in this production steered by learning machines? Is it possible to determine a probable learning curve for such machines and what can the probable effects of such corrections be, including cost, quality and, in a broader sense, environmental effects?

3. taking into consideration, if possible, in the prognostic business account, the life cycle of PBH production, incomes and costs, relevant and complete for every phase of this cycle as well as costs exceeding respectively far beyond the phase of liquidation of such a production.

REFERENCES

1. Drexler K. E., Engines of Creation, *.The Coming Era of Nanotechnology*, Nowy Jork: Anchor Books, Doubleday 1986, ISBN 0-385-19973-2

2. Gierszewska G., Romanowska R., Analiza strategiczna przedsiębiorstwa (Corporate strategic analysis), PWE Warsaw 2003.

3. Horngren Ch.T., Datar S.M., Foster G., Cost Accounting. A Managerial Emphasis, Twelfth Edition, Pearson. Prentice Hall, 2006.

4. Komunikat Komisji Europejskiej (Communication from the European Commission) „Europa 2020, *Strategia na rzecz intelektualnego i zrównoważonego rozwoju sprzyjającego włączeniu społecznemu (Europe 2020. A Strategy for Smart, Intellectual and Sustainable Inclusive Growth),* Brussels, 3 March 2010.

5. Taniguchi N, *On the Basic Concept of 'Nano-Technology'*, Proc. Intl. Conf. Prod. Eng. Tokyo, Part II, Japan Society of Precision Engineering, 1974.

6. Tsuji J.S., Maynard A.D., Howard P.C., James J.T., LamC., Warheit D.B., Santamaria A.B., Research Strategies for Safety Evaluation of Nanomaterials, Part IV: Risk Assessment of Nanoparticles, *Toxicol. Sci.* (January 2006) 89 (1)

Websites:
1) http://www.nano-technologie.pl/,
2) http://www.pa.msu.edu/~yang/RFeynman_plentySpace.pdf
3) http://www.nasa.gov/offices/oce/appel/ask-academy/issues/ask-oce/AO_1-8_F_small.html
4) http://www.futureforall.org/nanotechnology/risks.htm
5) http://www.risk.jbs.cam.ac.uk/)
6) http://www.lloyds.com/news-and-insight/risk-insight/reports/digital/managing-digital-risk,

MOBILE ADVERTISING ADOPTION: A PROPOSED EXTENDED UTAUT MODEL

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ABSTRACT

Purpose: Due to the advancement in mobile technologies, a new form of advertising has emerged. Mobile advertising (m-advertising) refers to the advertisement of products and services delivered via mobile devices (m-devices). While this alternative channel has created a new theme for research and has attracted many researchers, the study is still a neglected area among scholars. Therefore, the paper explores on the factors that influence consumers' behaviour to adopt m-advertising by proposing a conceptual framework.

Design/methodology/approach: To better understand the consumer's acceptance of m-advertising, the search for factors that motivate consumers behaviour to accept m-advertising is essential. This paper adopts Unified Theory of Acceptance and Usage of Technology (UTAUT) model as a foundation for framework. However, the adoption is also determined by personal innovativeness (PI) and mobile skillfulness (MS) and thus additional constructs have been proposed.

Research limitation/implication: This paper has limitations that need to be considered for validating the proposed conceptual framework. It is suggested that an empirical study is to be conducted for future research which includes structural equation modeling analysis in order to support the understanding of m-advertising adoption among consumers. The proposed conceptual framework provides references for scholars and mobile marketers to facilitate m-advertising growth in the mobile market environment.

Originality/value: By proposing additional constructs of PI and MS into UTAUT, the essential aim of this paper is to further validate and better understanding of consumers' adoption of m-advertising. Apart from this, the proposed extended model also provides

insights, awareness and an opportunity for mobile manufactures and service developers to create a successful m-advertising strategy.

Keywords: Mobile advertising (m-advertising), Unified Theory of Acceptance and Usage of Technology (UTAUT).

Classification: Conceptual paper

INTRODUCTION

The continuing growth of Internet coupled with higher penetration rate of mobile phones have created a new platform for marketing activity commonly known as mobile advertising (m-advertising). Marketers can use mobile messages to communicate with consumers on their products and services simply by using a mobile devices (m-devices) (Nasco and Bruner, 2008). Drossos and Giaglis (2006) elaborated that the improved technology has resulted the advancement in advertising broadcasting. Undoubtedly, m-advertising has the potential to reach the right consumers based on time and place (Maneesoonthorn and Fortin, 2006). Mobile phone is popular and widely adopted by most consumers for communication and entertainment purposes typically through short message service (SMS) and multimedia messaging service (MMS). In this respect, m-advertising is seen as an encouraging channel for mobile business due to the features of the communication devices, namely addressable, multimedia proficiencies and interactivity (Bulander et al., 2005).

Recognizing the advertising channels can be performed from a wired (e.g., fixed-line personal computers) to wireless environment (e.g., m-devices), the study on how consumers accept m-advertising is essential. The search on the critical factors that drive consumers behaviour towards m-advertising adoption is one of the major concerns by researchers and practitioners. Solomon et al. (2006) concluded that the role of consumers' attitude in influencing the acceptance of m-advertising is important as they primarily determine the key to acceptance. Tsang et al. (2004) highlighted that most literatures reported consumers have generally negative attitudes toward advertising. Therefore, a better understanding on how consumers feel about m-advertising should not be neglected. It is imperative to know what factors affect consumers' adoption of m-advertising which may in conformity with their positive attitudes toward adoption. Most past studies (e.g., Shuang, 2010; Zhang and Xiong, 2012) were mainly focusing on technology acceptance model (TAM) while little research was conducted on using Unified Theory of Acceptance and Usage of Technology (UTAUT) to examine the consumers' adoption of m-advertising. Based on this rationale, the paper serves as an initiave to close the literature gap by proposing a theoritecal-based understanding on the factors influencing consumers' favourable attitudes toward m-advertising.

In the following section, we discuss on the theoretical background on m-advertising adoption and UTAUT. Thereafter, the research propositions were designed to respond to our research

questions. We integrate personal innovativeness (PI) and mobile skillfulness (MS) into an extension of UTAUT in the development of our proposed conceptual framework. Finally, implications will be presented. This is follow by conclusion, limitations and suggestions for future research.

THEORETICAL BACKGROUND

M-advertising Adoption

With the continuous advancement of wireless communication equipments and wireless network technology, m-advertising will become a popular form of advertising in the future (Zhang and Xiong, 2012). M-advertising refers to "the business of encouraging people to buy products and services using the wireless channel as medium to deliver the advertisement message" (Interactive Mobile Advertising Platform, 2003 as cited in Shen and Chen, 2008, p. 158). M-advertising allows the sending of personalized, customised and unique advertisements (Turban et al., 2002) as well as dialogues and transactions involving consumers with the advertised brands (Drossos and Giaglis, 2006). According to Keshtgary and Khajehpour (2011), SMS, MMS, Bluetoth and Wireless Application Protocol (WAP) are the most famous m-advertising technologies currently adopted. Keshtgary and Khajehpour (2011) elaborated that SMS yielded approximately 90% of worldwide mobile market revenue; MMS allows text, photo, audio and video messages to be sent concurrently; Bluetooth used for short range between 1m to 100m location based services; whereas WAP sites allow connection of mobile phones to the Internet.

The Theory of UTAUT Model

Recently, the UTAUT model is increasingly given attention by researchers to explore on the users acceptance of technologies, for instance desktop computer applications (Al-Gahtani et al., 2007), e-learning system (Chen, 2011) and classroom technology (Lewis et al., 2013). UTAUT was developed by Venkatesh et al. (2003) which is an entension of TAM. In terms of explanatory value, UTAUT is able to explain 70 percent of the variance in usage intention in comparison to TAM. UTAUT was built by intergrating eight theories: "Theory of Reasoned Action (TRA), TAM, Motivational Model (MM), Theory of Planned Behavior (TPB), Combined TAM and TPB (C-TAM-TPB), Model of PC Utilization (MPCU), Innovation Diffusion Theory (IDT) and Social Cognitive Theory (SCT)" (Venkatesh et al., 2003, pp. 428-432).

The UTAUT model is comprised of four constructs in influencing user adoption and usage of an information technology. Three direct factors of intention to use are performance expectancy (PE), effort expectancy (EE) and social influence (SI); whereas intention and facilitating conditions (FC) denoted as the direct factors of usage behaviour (Venkatesh et al., 2003). Besides, Venkatesh et al. (2003) also included age, gender, experience and voluntariness of use as moderators to better understand on the complexity of individuals' technology acceptance. In this paper, we attempt to extent UTAUT model by integrating PI

and MS as additional direct factors of intention to use while the four moderators were excluded. We first propose introducing PI into UTAUT following suggestion from Rogers (2002) in the innovation diffusion theory whereby the adoption of a new product, idea or concept is predicted by individuals. We next incorporate the theory of social cognitive (Bandura, 1986), where MS is conceptualized as likelihood of individuals performing a complex mobile functions skillfully when they have greater advanced skills of using mobile phones (Lu and Su, 2009). The proposed conceptual framework is presented in Figure 1.

Figure 1: Proposed Conceptual Framework
(Adapted from Venkatesh et al., 2003)
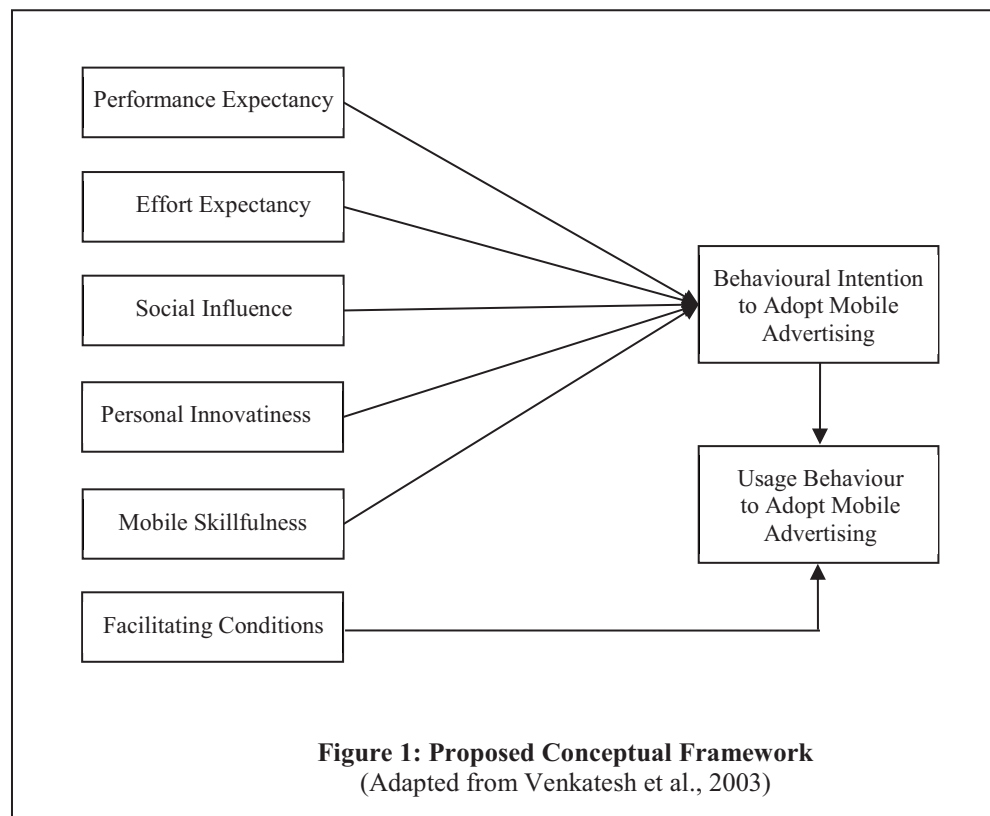
PROPOSITIONS DEVELOPMENT

Performance Expectancy (PE)

PE according to Venkatesh et al. (2012), refers to the level of an individual perceives that using a certain system or technology will assist in improving his/her performance. The theory of PE is equivalent to perceived usefulness (PU) of TAM (Venkatesh et al. 2003) and the theories of PU can be classified into three phrases: productivity, job effectiveness and importance of the system or technology to individual's job (Davis, 1989). Studies by Neufeld et al. (2007) and Wang and Yang (2005) have applied these theories and validated that PE has a significant effect on intention. Park et al. (2007) conducted an empirical study using 221 Chinese nationals and structural equation modelling analysis to explore on the adoption of mobile technologies. The study found that PE does impact significantly on attitude toward

m-devices. Another empirical study was carried out in Finland by Carlsson et al. (2006), in examining the application of UTAUT on the acceptance of m-devices and services. With data of 157 Finnish consumers, the proposed hypotheses were tested using linear regression analysis. The result verified that PE has a direct significant on intention to use m-devices and services. Based on the above studies, we believe that PE has a significant influence towards m-advertising intention. Therefore, we propose:

Proposition 1: PE is positively related to consumers' behavioural intention on m-advertising adoption.

Effort Expectancy (EE)

EE denotes as the level whereby an individual perceives a certain system or technology would be lesser efforts (Venkatesh et al., 2003). According to Rogers (1995), complexity of a particular system is one of the barriers of innovation. The acceptance of new system or technology will be higher when they believed that learning how to use the system is easy (Pikkarainen et al., 2004). Wong et al. (2012) elaborated that the more user-friendly of the system, the less barriers for consumers to use the new technology. In this case, ease of use and user friendliness will be the critical factors to uphold consumers' intention. In Marchewka et al's (2007) study based on a sample of 132 undergraduate and graduate business school university students in USA, result indicated that the construct of EE in UTAUT has a significant impact on the adoption of course management software (Blackboard). For these reasons, a well-designed system such as easy navigation structure and simplicity in design would encourage the consumers' intention towards m-advertising adoption when they found that using the system requires lesser efforts. Therefore, we propose:

Proposition 2: EE is positively related to consumers' behavioural intention on m-advertising adoption.

Social Influence (SI)

According to Karahanna et al. (1999), subjective norm (SN) is one of the elements of SI. SN according to Fishbein and Ajzen (1975) is "the person's perception that most people who are important to him think he should or should not perform the behavior in question" (p. 302). Choi et al. (2003) indicated that SN has the greatest influence on behavior intention, for example the opinions from a user's relatives, friends, peers, students, superiors and instructors (Lopez-Nicolas et al., 2008). Past works have confirmed SN to facilitate the understanding of use of behavioral intention towards an information system (Karahanna et al., 1999; Venkatesh and Davis, 2000). SN was further elaborated by Lu et al. (2003) that an individual's desire tends to influence how others think on performing a certain activity. For an example, friends, family, society or media may encourage an individual towards m-advertising intention and an individual will also rates others opinions on how easy and useful the system is. Past studies supported that SI has impact on mobile banking (Hong et al., 2008),

and 3G adoption (Chong et al., 2010). Based on the literature review, we believe that SI has a significant influence towards m-advertising intention. Therefore, we propose:

Proposition 3: SI is positively related to consumers' behavioural intention on m-advertising adoption.

Personal Innovatiness (PI)

Cotte and Wood (2004) defines PI as the level of an individual to adopt change and try new products or services. According to Rogers (1995), individuals who are innovative will be active in seeking new products and hence they are willing to try new technology. Generally, higher level of positive thinking for new technologies is generated by a higher level of PI (Lopez-Nicolas et al., 2008). Consumers are usually decline to change, buy and adopt new technology when they feel fear and anxiety in using the particular technology (Meuter et al., 2005). In a study by Limayem et al. (2000), they reported that PI has significantly impact on online shopping through consumers' attitude and intention. With the perception that highly innovative individuals are expected to cope with risks of uncertainty, they will have higher tendency to develop positive intention to use m-advertising. Therefore, we propose:

Proposition 4: PI is positively related to consumers' behavioural intention on m-advertising adoption.

Mobile Skillfulness (MS)

According to Lu and Su (2009), MS refers to the level of an individual to implement a specific task skillfully via a mobile phone. In the context of m-advertising, the skill refers to the ability of an user to execute a particular task via m-devices. When there is a shorter time needed to perform, consumers are more likely to accept the technologies and services. Previous study from Fagan et al. (2003) pointed out that a negative impact on an individual's perceived ability to perform a specified tasks skillfully is resulted from anxiety. However, consumer's intrinsic motivation can be enhanced with greater perception of the consumer's ability (Deng et al., 2004). In a study conducted by Lu and Su (2009), using a sample of 369 professional participants to test on customers' perspective on using mobile commerce services for mobile shopping, the findings revealed that consumer's self-perceptions of MS is a key determinant of intention to use. In the m-advertising context, we hold the expectation that MS is an interlinking concept that affects m-advertising adoption, which is: the more skillful the user in performing a specific task within a shorter time, the higher intention to adopt m-advertising. Theferore, we propose:

Proposition 5: MS is positively related to consumers' behavioural intention on m-advertising adoption.

Facilitating Conditions (FC)

FC refers to "the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system" (Venkatesh et al., 2003, p. 453). When users believe the existence of resources and technical facilities to support the systems, they will have higher expectation to adopt them (Pahnila et al., 2011). Based on past studies, sufficient software and hardware resources, IT knowledge and availability of technical support are likely to reduce barriers of using a new technology and subsequently expedite the actual use of it (Chang et al., 2007; Im et al., 2011). AlAwadhi and Morris (2008) surveyed 880 students to examine e-government services adoption and the result proved that FC has a significant impact on the use of it. In accordance to the above findings, we believe that the tendency of individuals to use m-advertising is higher if they have adequate resources available. Therefore, we propose:

Proposition 6: FC is positively related to consumers' usage on m-advertising adoption.

Usage Behaviour

According to Venkatesh et al. (2003), the behavioural intention to use a technology will help to support actual behaviour. The behaviour intention belief is regarded as an anchor for using behaviour in future, in which individuals tend to rely on their initial impressions of future beliefs (Venkatesh et al., 2003). A number of researchers have conducted empirical studies and supported this assumption, for instance e-government services (AlAwadhi and Morris, 2008) and Chinese eBay/Tao Bao (Pahnila et al., 2011). Consistent with the outcome expectation theory, we suggest that behavioural intention to use is a predictor of actual behaviour of m-advertising. Therefore, we propose:

Proposition 7: Consumers' behavioural intention on m-advertising adoption is positively related to the consumers' usage behaviour.

IMPLICATIONS

In order to support m-advertising growth, it is imperative to determine the key factors that drive m-advertising adoption from consumers' point of view. This paper proposed an extension of UTAUT by integrating PI and MS as additional direct factors of intention to use in influencing the m-advertising adoption among consumers.

Following past studies' suggestion on the adoption of UTAUT in predicting different technologies adoption, we adopted three direct factors (i.e. PE, EE and SI) of intention to use and a direct factor (i.e. FC) of usage behaviour. In order to provide deeper insights in understanding the adoption of m-advertising among consumers, we integrated PI and MS into the proposed conceptual framework. The proposed conceptual framework provides the following guidelines for scholars and mobile marketers to facilitate m-advertising growth in the mobile market environment. Firstly, since PE may be significant, hence mobile marketers

and advertising industries should focus on user-oriented design to promote the usefulness of m-advertising. Secondly, mobile manufacturers should focus on designing the m-devices to be more user-friendly, user manual and online helpdesk must be easy to learn and use to increase the level of EE. Thirdly, as SI of an individual to adopt m-advertising may be influenced by friends, family, society, peers, mass media etc, practionners can consider to promote m-advertising in social networks or electronic word-of-mouth channels such as "Facebook" and "Friendster". Fourthly, when PI is believed to have impact on behavioural intention to use m-advertising, marketing plans should be designed to cater to a specific group of innovative users in the society who are willing to take risk on using new technology. Fifthly, MS is expected to encourage the acceptance of m-advertising, therefore retailers should consider to organize users training programs to help mobile users in using m-devices skillfully and to reduce their anxiety. Lastly, in order to uplift the usage rate of m-advertising, practitioners should provide sufficient internal/external resources and technical infrastructure (e.g., WiFi) when FC is believed to have significant effect on actual use of it.

CONCLUSION, LIMITATIONS AND FUTURE RESEARCH

Overall, this paper propose an extension of UTAUT to identify factors that drive consumer behaviour towards m-advertising adoption from the consumers' point of view. By proposing additional constructs of PI and MS into UTAUT, the essential aim of this paper is to further expand and better understanding on the consumer adoption of m-advertising. Additionally, the proposed extended model also provides insights, awareness and an opportunity for mobile manufactures and service developers to create a successful m-advertising strategy. This paper has limitations that need to be considered for validating the proposed conceptual framework. It is suggested that data should be collected from empirical study in future research and using the appropriate analysis such as structural equation modeling to validate the findings.

REFERENCES

1. AlAwadhi, S., and Morris, A. (2008), "The Use of The UTAUT Model in the Adoption of E-Government Services In Kuwait", *Proceedings of the 41st Hawaii International Conference on System Sciences*, Hawaii, pp. 1-11.
2. Al-Gahtani, S.S., Hubona, G.S., and Jijie, W. (2007), "Information Technology (IT) in Saudi Arabia: culture and the acceptance and use of it", *Information & Management*, Vol. 44 No. 8, pp. 681-691.
3. Bandura, A. (1986), *Social Foundations of Thought and Action*, Prentice-Hall, Englewood Cliffs, NJ.
4. Bulander, R., Decker M., Schiefer G., and Kolmel, B. (2005), "Comparison of Different Approaches for Mobile Advertising", *Proceedings of the 2nd IEEE International Workshop on Mobile Commerce and Services (WMCS'05)*, IEEE Computer Society, Munich, Germany, pp. 174-182.

5. Carlsson, C., Joanna, C., Hyvönen, K., Puhakainen, J., and Walden, P. (2006), "Adoption of Mobile Devices/Services – Searching for Answers with the UTAUT", *Proceedings of the 39th Hawaii International Conference On System Sciences*, Hawaii.

6. Chang, I.C., Hwang, H.G., Hung, W.F., and Li, Y.C. (2007), "Physicians' acceptance of pharmacokinetics-based clinical decision support systems", *Expert Systems with Applications*, Vol. 33 No. 2, pp. 296-303.

7. Chen, J.L. (2011), "The effects of education compatibility and technological expectancy on e-learning acceptance", *Computers & Education*, Vol. 57 No. 2, pp. 1501-1511.

8. Choi, H., Choi, M.S., Kim, J.W., and Yu, H.S. (2003), "An empirical study on the adoption of information appliances with a focus on interactive TV", *Telematics and Informatics*, Vol. 20 No. 2, pp. 161-183.

9. Chong, A.Y.L., Darmawan, N., Ooi, K.B., and Lin, B. (2010), "Adoption of 3G services among Malaysian consumers: an empirical analysis", *International Journal Mobile Communications*, Vol. 8 No. 2, pp. 129-149.

10. Cotte, J., and Wood, S.L. (2004), "Families and innovative consumer behavior: a triadic analysis of sibling and parental influence", *Journal of Consumer Research*, Vol. 31 No. 1, pp. 78-86.

11. Davis, F.D. (1989), "Perceived usefulness, perceived ease of use, and user acceptance of information technology", *MIS Quarterly*, Vol. 13 No. 3, pp. 319-339.

12. Deng, X., Doll, W., and Truong, D. (2004), "Computer self-efficacy in an ongoing use context", *Behaviour and Information Technology*, Vol. 23 No. 6, pp. 395-412.

13. Drossos, D., and Giaglis, G.M. (2006), "Mobile Advertising Effectiveness: An Exploratory Study", *Proceedings of the International Conference on Mobile Business (ICMB'06)*.

14. Fagan, M.H., Neill, S., and Wooldridge, B.R. (2003), "An empirical investigation into the relationship between computer self-efficacy, anxiety, experience, support and usage", *Journal of Computer Information Systems*, Vol. 44 No. 2, pp. 95-104.

15. Fishbein, M., and Azjen, I. (1975), *Beliefs, Attitudes, Intention, and Behavior: An Introduction of Theory and Research*, Addison-Wesley, Massachusetts, USA.

16. Hong, S.J., Thong, J.Y.L., Moon, J.Y., and Tam, K.Y. (2008), "Understanding the behavior of mobile data services consumers", *Information Systems Frontier*, Vol. 10 No. 4, pp. 431-445.

17. Im, I., Hong, S., and Kang, M.S. (2011), "An international comparison of technology adoption: testing the UTAUT model", *Information & Management*, Vol. 48 No. 1, pp. 1-8.

18. Karahanna, E., Straub, B., and Chervancy, N. (1999), "Information technology adoption across time: a cross-sectional comparison of pre-adoption and post-adoption beliefs", *MIS Quarterly*, Vol. 23 No. 2, pp. 183-213.

19. Keshtgary, M., and Khajehpour, S. (2011), "Exploring and analysis of factors affecting mobile advertising adoption - an empirical investigation among Iranian users", *Canadian Journal on Computing in Mathematics, Natural Sciences, Engineering and Medicine*, Vol. 2 No. 6, pp. 144-151.

20. Lewis, C.C., Fretwell, C.E., Ryan, J., and Parham, J.B. (2013), "Faculty use of established and emerging technologies in higher education: a unified theory of acceptance and use of technology perspective", *International Journal of Higher Education*, Vol. 2 No. 2, pp. 22-34.

21. Limayem, M., Khalifa, M., and Frini, A. (2000), "What makes consumers buy from Internet? A longitudinal study of online shopping", *IEEE Transactions on Systems, Man, and Cybernetics – Part A: Systems and Humans*, Vol. 30 No. 4, pp. 421-432.

22. Lopez-Nicolas, C., Molina-Castillo, F.J., and Bouwman, H. (2008), "An assessment of advanced mobile services acceptance: contributions from TAM and diffusion theory models", *Information and Management*, Vol. 45 No. 6, pp. 359-364.

23. Lu, H.P., and Su, P.Y.J. (2009), "Factors affecting purchase intention on mobile shopping websites", *Internet Research*, Vol. 19 No. 4, pp. 442-458.

24. Lu, J.Y., Liu, C.S., and Yao, J.E. (2003), "Technology acceptance model for wireless Internet", *Internet Research: Electronics Networking Applications and Policy*, Vol. 13 No. 3, pp. 206-222.

25. Maneesoonthorn, C., and Fortin, D. (2006), "Texting behaviour and attitudes towards permission mobile advertising: an empirical study of mobile users' acceptance of SMS for marketing purposes", *International Journal of Mobile Marketing*, Vol. 1 No. 1, pp. 66-72.

26. Marchewka, J.T., Chang, L., and Kostiwa, K. (2007), "An application of the UTAUT model for understanding student perceptions using course management software", *Communications of the IIMA*, Vol. 7 No. 2, pp. 93-104.

27. Meuter, M.L., Bitner, M.J., Ostrom, A.L., and Brown, S.W. (2005), "Choosing among alternative service delivery modes: an investigation of customer trial of self-service technologies", *Journal of Marketing*, Vol. 69 No. 2, pp. 61-83.

28. Nasco, S.A., and Bruner, G.C. (2008), "Comparing consumer responses to advertising and non-advertising mobile communication", *Psychology & Marketing*, Vol. 25 No. 8, pp. 821-837.

29. Neufeld, D.J., Dong, L., and Higgins, C. (2007), "Charismatic leadership and user acceptance of information technology", *European Journal of Information Systems*, Vol. 16 No. 4, pp. 494-510.

30. Pahnila, S., Siponen, M., and Zheng, X. (2011), "Integrating habit into UTAUT: the Chinese eBay case", *Pacific Asia Journal of the Association for Information Systems*, Vol. 3 No. 2, pp. 1-30.

31. Park, J., Yang, S., and Lehto, X. (2007), "Adoption of mobile technologies for Chinese consumers", *Journal Of Electronic Commerce Research*, Vol. 8 No. 3, pp. 196-206.

32. Pikkarainen, T., Pikkarainen, K., Karjaluoto, H., and Pahnila, S. (2004), "Consumer acceptance of online banking: an extension of the technology acceptance model", *Internet Research*, Vol. 14 No. 3, pp. 224-235.

33. Rogers, E. (1995), *Diffusion of Innovations*, 4th ed., The Free Press, New York, NY.

34. Rogers, E. (2002), "Diffusion of preventive innovations", *Addictive Behaviors*, Vol. 27 No. 6, pp. 989-993.

35. Shen, X., and Chen, H. (2008), "An Empirical Study of What Drives Consumers to Use Mobile Advertising in China", *The 3rd International Conference on Grid and Pervasive Computing – Workshops*, pp. 158-163.

36. Shuang, X. (2010), "A Conceptual Framework for Consumer Adoption of Mobile Advertising in China", *International Conference on E-Business and E-Government*, pp. 74-77.

37. Solomon, M., Bamossy, G., Askegaard, S., and Hogg, M.K. (2006), *Consumer Behaviour: A European Perspective*, 3rd ed., Prentice Hall, New Jersey.

38. Tsang, M.M., Ho, S.C., and Liang, T.P. (2004), "Consumer attitudes toward mobile advertising: an empirical study", *International Journal of Electronic Commerce*, Vol. 8 No. 3, pp. 65-78.

39. Turban, E., King, D., Lee, J., Warkentin, M., and Chung, H.M. (2002), *Electronic Commerce: A Managerial Perspective*, Prentice-Hall, Upper Saddle River, New Jersey.

40. Venkatesh, V., and Davis, F. (2000), "A theoretical extension of the technology acceptance model: four longitudinal field studies", *Management Science*, Vol. 46 No. 2, pp. 186-204.

41. Venkatesh, V., Morris, M.G., Davis, G.B., and Davis, F.D. (2003), "User acceptance of information technology: toward a unified view", *MIS Quarterly*, Vol. 27 No. 3, pp. 425-478.

42. Venkatesh, V., Thong, J.Y.L., and Xu, X. (2012), "Consumer acceptance and use of information technology: extending the unified theory of acceptance and use of technology", *MIS Quarterly*, Vol. 36 No. 1 pp. 157-178.

43. Wang, H.I., and Yang, H.L. (2005), "The role of personality traits in UTAUT model under online stocking", *Contemporary Management Research*, Vol. 1 No. 1, pp. 69-82.

44. Wong, C.H., Lee, H.S., Lim, Y.H., Chua, B.H., and Tan, G.W.H. (2012), "Predicting the consumers' intention to adopt mobile shopping: an emerging market perspective", *International Journal of Network and Mobile Technologies*, Vol. 3 No. 3, pp. 24-39.

45. Zhang, X.Y., and Xiong, K. (2012), "A Conceptual Model of User Adoption of Mobile Advertising", *International Conference on Computer Science and Electronics Engineering*, pp. 124-127.

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MODULAR APPROACH TO PRODUCT VARIANT DESIGN USING KBE

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ABSTRACT

Purpose: *Research described in the paper was aimed at development of a modular system for automation of product variant design. The developed Automatic Design System (ADS) was a result of a cooperation between the production company and the university and was implemented in order to shorten time of implementing a new variant into production. It is a software tool dedicated for design engineers and process engineers and is used for preparation of technical documentation (CAD data) of copper tube couplings and bent pipes and planning of a manufacturing process (CAM) of tooling necessary to manufacture these products by forging and bending respectively.*

Design/methodology/approach: *The system described in the paper is a modular knowledge-based software solution. The knowledge about the product family – structure, geometry, materials, process stages, etc., was gathered and implemented inside a CAD/CAM system. Auto-generating models were prepared, containing sets of solid modeling operations and sets of relations between product parameters. The relations were defined as both mathematical and logical functions (rules). Automation was realized using customized macros to remotely launch particular sequences for generation of CAD models and CAM programs.*

Findings: *Application of KBE system for design automation for copper tube couplings allowed reduction of the time needed for CAD and CAM operations for a single product variant from 35 hours to less than 8 hours. For bent pipes, time reduction (CAD design, CNC programming) was from 8-10 hours to less than 2 hours for a single product variant.*

Originality/value: *The system was a solution to a tangible industrial problem and it has been successfully implemented in a production company. It allowed great time reductions in design and process planning. The applied methodology was innovative and the developed*

solutions are flexible – they can be used to automate design and process planning in many other cases of variant products.

Keywords: knowledge-based engineering, automatic design systems, CAD/CAM systems, product variant design

Classification: Research paper

INTRODUCTION

Development of computer software tools – CAx systems – aiding the engineering work, allows management of knowledge in a more effective way. Nowadays, on each stage of a new product development, the decisions that are made can be described and the experience acquired this way can be analyzed. Gathered information can be used again, aiding the future decision-making processes and hastening realization of routine, often repeated tasks. Process of implementation of the gathered knowledge in new solutions, aimed at its reuse, is a base of all problems related to building engineer systems based on knowledge (Knowledge Based Engineering, KBE) (Verhagen et al., 2012).

An example, allowing practical verification of possibilities of the KBE systems, is a process of design of variant products, which means products similar both in construction and methods of manufacturing but differing in some features. Unique description of these features is a definition of a specific variant. Characteristics of such a process should focus not only on the design tasks, but also on product features, along with conditions of their occurrence and relations between parameters needed for description of these features. If this description can be applied to all variants of a given set, then in practical application the KBE allows to automate practically the whole design process (Zawadzki, 2013, Tiwari et al., 2013).

Most of the presently operating manufacturing companies, also small and medium sized, already use advanced CAx systems, aiding both the design and the manufacturing processes. Apart from tools for the design of a product, its manufacturing process and verification of a virtual project, these programs offer, among other things, special tools out of the KBE family. These tools allow effective gathering of knowledge of experts and specialists about specific processes (Skarka, 2009, Pokojski, 2005). The companies dealing with production of variant products, striving to meet the often changing market requirements, must be manufacturing with some flexibility, which is obviously related to readiness of introducing frequent design changes (Mleczko, 2011). Effectiveness of these changes is decided by a proper technical preparation of the company and short time of their implementation. These factors are strictly related to the knowledge, its appropriate recording and implementation in a given solution and automation, which allows results to be quickly obtained (Skarka, 2007). A proper representation of the design knowledge is therefore important for the company, also from the

economical point of view. Faster design with the same correctness directly translates into time and cost savings.

In the scope of the technical preparation, it is necessary to determine the scale of the design process, for which the knowledge is gathered and saved. Work of the design engineers is often not done after the technical documentation of a given product is prepared – it continues with design of the tooling used for the product manufacturing. Rules of construction of this tooling often form a separate set of technical conditions and their design requirements often influence the final shape of the product itself. For the design department, full design documentation related to a given product variant is a complete set of data necessary for realization of the task, that is why KBE systems are often expected to present a complex approach, incorporating all the activities related to preparation of the technical documentation (Zawadzki, 2013).

The design process of the variant products is related not only with development of the product geometry, but also with preparation of the manufacturing process. The KBE tools also offer support in this area. It is possible to record the gathered knowledge in the form of rules and laws, aimed at working out the best strategy for processing a given variant of product or tool. Integrated CAD/CAM systems join both stages of the work, ensuring data compatibility and simplified information exchange between subsequent levels of the KBE system. Range of support of work at this stage might be crucial for a new solution, both in terms of results correctness and time.

Other requirements can also be set for knowledge-based systems aiding the engineer's work. These requirements can be related to updating, service and access, to already saved knowledge. For the company, it could be important to benefit from the dedicated solutions, which allow use of the knowledge bases not only by design or manufacturing preparation departments but also by other company divisions dealing with sales, marketing or management. Sharing the KBE system with many users, e.g. salesmen, contractors or customers, without direct access to the CAx system, but with use of knowledge recorded there, may become one of the basic requirements set for the new solutions. Then, it becomes a challenge to develop complex solutions, allowing not only the implementation and application of the knowledge, but also its management (La Rocca, 2012, Abdullah et al., 2006, Darai et al., 2010).

An example of a solution meeting the above-mentioned requirements may be an Automatic Design System (ADS) – a modular solution aiding the design and manufacturing process preparation of variant products, described in this paper.

RESEARCH DESIGN AND METHODOLOGY

Modular structure of the Automatic Design System

An Automatic Design System is a tool prepared for automation of the design processes of variant products. Shape of these products is a new configuration contained in a given series of types. Each configuration is unique and entirely new. This is why the new product variant preparation requires performing some design activities from the scratch (Zawadzki, 2013).

Particular variants in a given series of types differ in values of the parameters that describe them. This is why, in theory, a single parameter change is all it takes to get an entirely new configuration. Analysis of the variant product design process, requirements set by the design offices and available tools, including KBE techniques, allowed definition of basic requirements for the system:

- automation of the design process, including preparation of the technical documentation of the product and used tools,
- automation of the manufacturing preparation process for products or tooling used for their manufacturing,
- assurance of possibility of saving, implementing and updating the engineering knowledge,
- assurance of process standardization and procedure unification in the whole company,
- assurance of constant access to resources and possibility of easy operation,
- assurance of support regarding manufacturing cost calculation,
- assurance of remote access, with possibility of multi-user access.

The basic tasks of the ADS system, related to preparation of geometry of a new product and recording the relations between design parameters, are based upon a parametric CAD/CAM system. Systems available on the market allow use of different programming languages, which is why they are not only engineering design tools but integrated design and programming environments most of all. Thanks to this, all the important information about new configuration can be entered into the program remotely, and results can be effectively transferred to other units of the ADS. This allows different design tasks to be joined and automated and assures data compatibility in all modules of the system:

- CAD model construction module,
- CAM manufacturing process preparation module,
- results verification module,
- system operation module – user interface,
- product and process data analysis module,
- administrative module.

The modules can be implemented separately, realizing only the selected requirements. Processes of design of variant products are much more different from each other, as they can

include single components or complex sets. This is why the final shape of the system can be different each time. In such a case, the system can be called a dedicated solution, which is prepared to meet specific requirements of the process.

Basic structure of the system (Fig. 1) includes all the modules created during work on the ADS.
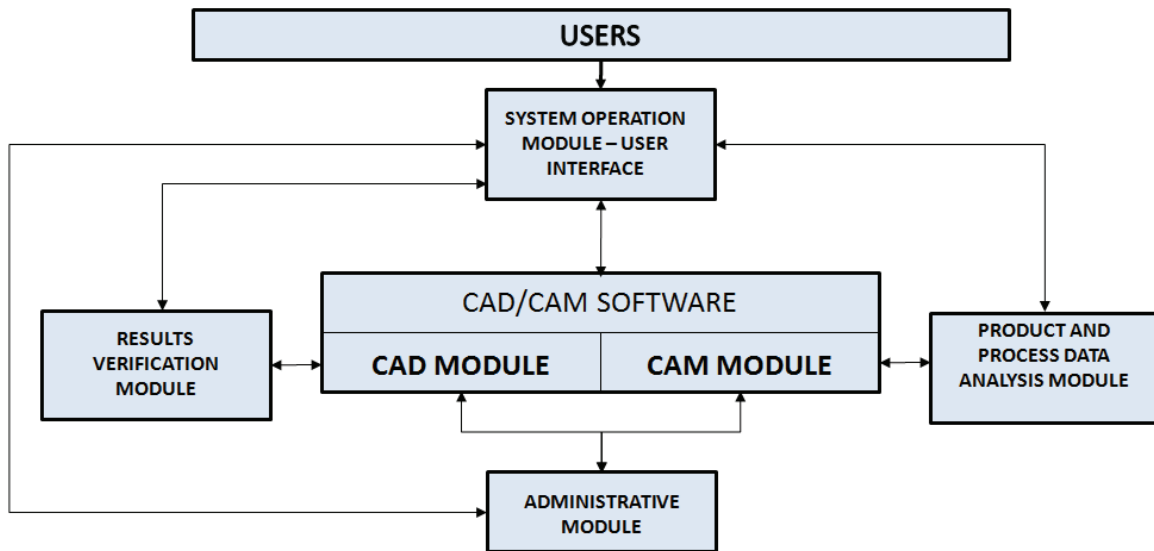
Fig. 1. Modular structure of the Automated Design System

The user interface module is needed to ensure friendly and easy access to the ADS resources for all users. It can be responsible for the remote operation, when building a network solution, or facilitate navigation through the system options on a level of the CAD/CAM system.

The module of the ADS administration is a dedicated managing application, allowing remote control of the system, also for multiple users. In this module, information about authorizations, task queuing, and module connections is stored. In the case of the network solution, the administrative module is responsible for the data exchange in the system.

The CAD module is responsible for automatic generation of all the 3D models included in the implementation (product and tooling). In most cases, it is related with the so-called autogenerative models (Skarka, 2009), which are models created using KBE tools available in the CAD system. In this module, knowledge about the design process is stored and can be updated at a later time.

The verification module is related to validation of results in the form of saved CAD models. At this stage, procedures and tools are prepared that allow determination of compatibility of the automatically generated product variant with previous assumptions.

The manufacturing process preparation module is an option of the ADS and is responsible for automation of the manufacturing processes preparation stage. CAM operations are used here, on the basis of the knowledge recorded using KBE tools, and macros are responsible for the automation.

A module of the product and the process data analysis is prepared for departments of manufacturing, planning and sales. Data from the CAD and CAM modules (product mass, semi-finished product shape, amount and type of standardized machine elements, number of manufacturing operations, machining time, etc.) can be used, for example, to prepare an offer for customers or contractors.

Acquiring, recording and implementation of knowledge

A basic module of the Automated Design System is the CAD module. In this module, the knowledge gathering process is started. The gathered knowledge about the design process is usually vast and dispersed, which causes problems of its recording on the initial stage (Pokojski, 2009). It is important to classify the knowledge with respect to its source, mainly including:

- technical standards,
- company standards,
- experimental knowledge,
- expert knowledge
- prepared procedures,
- trainings, etc. (Dostatni, 2007)

The first tasks of knowledge gathering are strictly related to definition of the series of types, for which the automation is prepared. During these actions, a family of variant products is described, creating classification of products similar by geometry and CAD model preparation process, but also affinity of the manufacturing processes (Duda, 2013). The series of types description is based on definition of the product basic features and selection of limiting values of its parameters. On this basis, already realized projects matching the described pattern are selected for further analysis, strictly related to the CAD modeling. At this stage, standardization of the model building process is implemented. If the same geometrical element was built using several different methods, one of them is selected as a standard and the rest are discarded. Next, information about relations between particular geometrical elements and parameters describing them is gathered. Hidden knowledge of the experts is joined with the commonly accessible knowledge, described in the technical standards. Information on relations between parameters and conditions of their occurrence, options, values, exclusions and extortions, is a base for knowledge implementation in the KBE system.

Knowledge of manufacturing processes is gathered in a similar way. Classification of manufacturing technology is created on the basis of the previously prepared division for the product and the tooling. Already used processes are subjected to analysis in order to build one model process, named a template process (Skarka, 2009, Duda, 2013). Features and parameters are divided into classes and relations and rules between these features are determined. Basic operations and settings are defined. Economical coefficients of the process are taken into account, along with conditions of tool or machine selection. This information is gathered for future automation (Zawadzki et al., 2011).

Building a KBE-class system, including the ADS, requires gathering data about course of the data exchange in the design process. Defining values of basic parameters, describing a given variant (e.g. dimensions, shape, production size or material) is often done by the contractors or end recipients, not in the design office of the manufacturer. Later, this information is processed in the manufacturing company, by different departments. Knowledge about how the order is realized has an influence on structure and shape of the ADS, this is why it should be recorded in an appropriate form, e.g. in the form of data flow maps.

The gathered and recorded knowledge of the design process is implemented in the CAD/CAM system, using available KBE tools. In the CAD module, autogenerative models are prepared. Their structure consists not only of a set of modeling operations but also of a description of relations between parameters. All arithmetical relations are described by mathematical functions, while logical relations (e.g. exclusions, conditions of occurrence, intervals) are implemented by so-called rules. For knowledge recording and implementation, dedicated databases or simple design tables are used. Such a solution allows the data exchange and communication between modules. The automation is realized by macros, which are used for remote launching of particular sequences of the CAD models building.

Work on the CAM module of the ADS is carried out in a similar way, as the same KBE tools are used. Gathered knowledge of the manufacturing processes is used to build templates describing plans of the material processing operations (Duda, 2013). The templates contain information about operations, tools and characteristic elements of the object geometry, e.g. points, edges, surfaces, which in connection with properly prepared CAD models allow automatic generation of the manufacturing program for a given variant. Set of parameters and their values can be stored in databases and tables, which allow easy access during analysis of the production costs and preparation of an offer for a client.

Part of the knowledge of the data exchange is implemented in the Automatic Design System on a level of the administrative module. The work consists in building an application supervising the communication, macro launching, recording data to the database and access via network for multiple users. This module contains a logic for data queuing and stores information about users and their authorizations (Zawadzki et al., 2011).

Examples of Automation Design Systems

Below, selected solutions of the ADS are presented, developed as research and development work with the industrial manufacturing companies.

System for design of copper couplings

Aim of this solution was an automation of tasks related to preparation of 3D models for new configurations of products and manufacturing tools necessary for their production: dies, mandrels, punching dies and punches. The range of offered product variants, due to variable geometrical elements and dimensions, consists of several thousand possible solutions (Fig. 2). The ADS was also used for preparation of the Computer Numerical Control program for die machining. A standard design/modeling process before ADS implementation lasted from several to over a dozen hours. The design accepted for manufacturing required several more hours of work in the CAM software (Zawadzki, 2013).
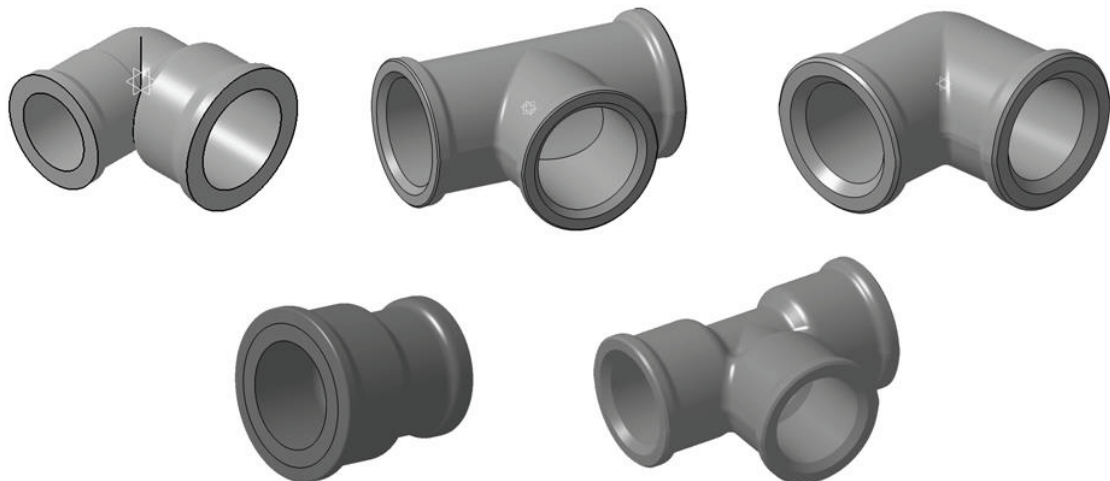
Fig. 2. Examples of various variants of models of the copper couplings

The ADS contained 5 modules (Fig. 3):

- system operation module – user interface,
- CAD models building module,
- CAM manufacturing process design module,
- result verification module,
- administrative module.
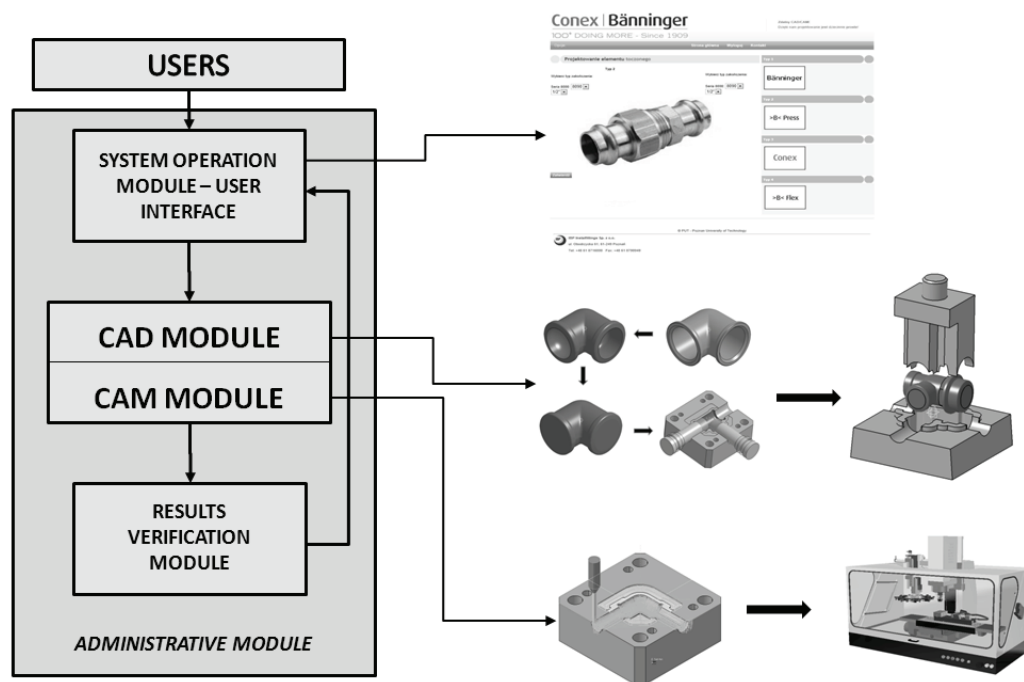
Fig. 3. Scheme of the ADS for copper couplings

Because of simplification and routine character of work on the design of a new product variant, attempts were made at standardization of this process and unification of practices were applied in the company by implementation of the KBE techniques. Initially, one order required several people to work on it: a design engineer, a process engineer or engineers from units making the order. To simplify the operation and allow many people to work at once, a proper user interface module was prepared. A network configuration was used, along with remote connection to the knowledge database of the CAx system. Special emphasis was put on the data flow, starting from parameter definition through verification of the variant geometry, to preparation of the CNC program for the die milling. The network structure allowed an increase of the performance of the available computer equipment, by possibility of planning and launching the process of tool path generation in the night hours (Zawadzki and Kuczko, 2013).

Conducted tests of the ADS, prepared for selected product families, have shown that time savings can even be up to 80%. Comparison of methods in range of times of realization of basic design tasks is shown in Table 1.

Table. 1. Average times of design activities for the copper couplings

Standard design process		ADS design process	
Task	Time	Task	Time
Design of a die forging	11h 20min	**Data input for a new product**	25min
Design of a die with forming mandrels	7h 45min	**Calculation of parameters, generation of the complete data set**	40min
Design of a trimming die	3h 45min	**Analysis and control of generated data**	6 h
Preparation of the machining process of the die with the mandrels	9h 45min		
Preparation of the machining process of the trimming die	2h 45min		
TOTAL	**35h 15min**		**7h 5min**

System for design of bent pipes

The individual character of the product places the process of a new pipe design at the start of the stage of preparation of an offer for a client. A project of the piping is always unique and shapes and dimensions of pipes can be different (Fig. 4). Lack of repeatability of projects of pipe installations requires making 3D models of each pipe on the initial stage of offer and pricing preparation. Studies carried out on this subject have shown that an average time of design of a single product was over 7 hours (Zawadzki et al., 2014).

Fig. 4. Examples of various variants of models of pipe installations

In this case, the ADS was built out of 6 modules:

- system operation module – user interface,
- CAD models building module,
- manufacturing process design module,
- result verification module,
- product and process data analysis module,
- administrative module.

The user interface module is responsible for input of data about a new variant. The data are, among other things, coordinates of the bending points, radiuses, pipe diameters and connection and pipe end types.

The CAD module automatically builds a complete 3D model of a product: single pipe with ends (couplings) and pipe consisting of several single ones. On the basis of the CAD model, data analysis module, in cooperation with the user interface module, presents calculation of the production costs, taking the whole manufacturing process into account, together with costs of material, standardized elements, etc. In the CAM module, a user can generate a program for the CNC bending machine for a given pipe variant. The scheme of the system is presented in Figure 5.

By using the available tools, e.g. macros, relations between parameters, rules for numerical values and logical conditions, an algorithm for automatic pipe model generation was prepared. Data for the model building was collected from appropriately prepared tables, which were based on the basic values entered into the system by a user from the interface level. The following steps are automated:

- creation of a new product and part file,
- filename changing,
- creation of points in 3D space, determining a pipe geometry,
- creation of sketches and solid model of a pipe,
- creation of additional geometrical elements,
- insertion of pipe ends (couplings),
- assigning material properties.
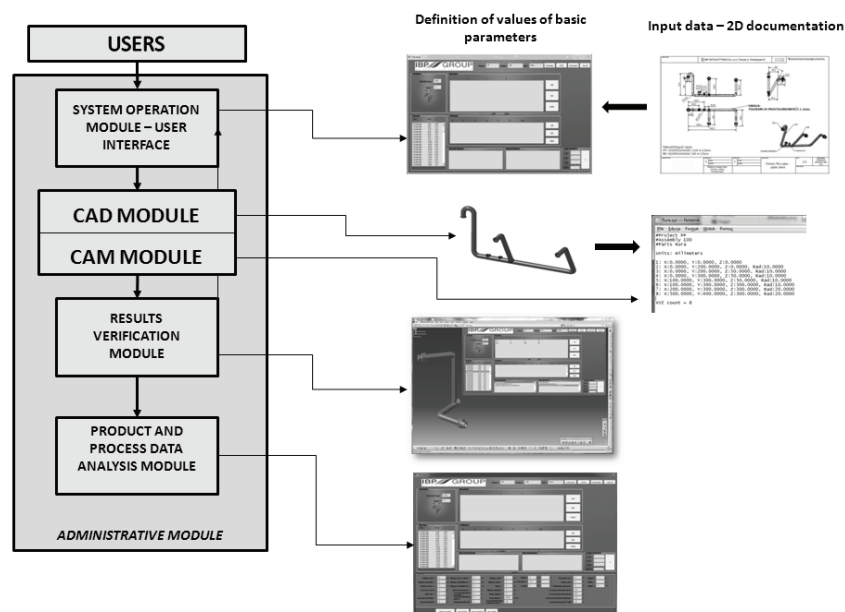
Fig. 5. Scheme of ADS for bent pipes

Implementation of automation of the design process and manufacturing preparation process allowed shortening of the time needed for preparation of an offer for a client and launching production of a new product variant. Time consumption of the design and documentation preparation processes was reduced more than 80%. A standardization of manufacturing processes also needs to be recognized as a beneficial change. Already on the stage of tests of the new system, significant time savings were observed:

- input of new product data – 45 min. on average, instead of 7 hours,
- automatic generation of a complete data set for a new product – 10 min. on average, instead of 2 hours,
- analysis and control time – 45 min. on average.

Comparison of methods concerning times of realization of basic design tasks is presented in Table 2.

Table. 2. Average times of design activities for the bent pipes

Standard design process		ADS design process	
Task	Time	Task	Time
Design of a new product	7h 20min	**Data input for a new product**	45min
Preparation of the bending process	2h 20min	**Calculation of parameters, generation of the complete data set**	10min
		Analysis and control of generated data	45min
TOTAL	**9h 40min**		**1h 40min**

CONCLUSIONS

Frequently, knowledge-based design systems are dedicated solutions. Modular approach to their structure, in the case of design of variant products, gives a large freedom of choice of the proper components and allows fulfillment of specific needs of the design process. A base element of the whole system is always a CAD module because a 3D model allows different configurations to be easily described. The product geometry also supplies information necessary for the manufacturing process planning and allows quick verification of the prototype. Other modules, related to process planning, cost analysis and system operation, are always built "around" the CAD module.

A significant part of design offices dealing with the variant products do not fully utilize the potential of knowledge-based solutions or do not use them at all. One of the causes of such a state is a fact that application of the KBE tools available in the CAx systems is not easy. It requires the engineers to not only have considerable experience in the design itself

(construction, manufacturing processes), but also be skilled in programming. This is why work on building or updating knowledge-based systems is often realized by teams of engineers and programmers. For the company, it is often related to an extra investment and continuous changes in range of offered products are an additional difficulty. Another cause of limitations in building of such systems is time consumption of such a process. It is possible that during studies on gathering and implementation of the knowledge, the product will change its characteristics completely or its production will be suspended or ceased.

Implementation of systems of the KBE class is one of the methods to preserve the know-how of a company. Some studies show that, frequently, much information about design processes functioning in a company is a knowledge which was never before recorded, being only an expert knowledge resulting from the experience of people working in a given company. This is why solutions similar to the presented Automation Design System are a guarantee of maintaining and proper transfer of the design knowledge.

REFERENCES

1. Verhagen W. J.C., Bermell-Garcia P., Reinier Van Dijk E.C., Curran R.,: "A critical review of Knowledge-Based Engineering: An identification of research challenges", Advanced Engineering Informatics 26, 2012, pp. 5–15.
2. Zawadzki P.,: "Automatic design of variant products with application of knowledge-based techniques", Inżynieria Maszyn, vol. 18, 1/2013, pp. 30-39.
3. Tiwari V., Jain K. P., and Tandon P., "Design Process Automation Support through Knowledge Based Engineering", Proceedings of the World Congress on Engineering 2013 Vol II, WCE 2013, July 3 - 5, 2013, London, U.K.
4. Skarka W.,: "Podstawy budowy modeli autogenerujących" („Basic information about autogenerative models building"), Wydawnictwo Helion, 2009.
5. Pokojski J.,: "Systemy doradcze w projektowaniu maszyn" („Expert systems in mechanical engineering design"), Wydawnictwo WNT, 2005.
6. Mleczko J.,: "Flow of Data in the Operational Management of Configurable Products", Zarządzanie Przedsiębiorstwem, Issue 1, 2011, pp. 17-26.
7. Skarka W., "Application of MOKA methodology in generative model creation using Catia", Engineering Applications of Artificial Intelligence 20 (2007), pp. 677–690.
8. La Rocca G., " Knowledge based engineering: Between AI and CAD. Review of a language based technology to support engineering design", Advanced Engineering Informatics 26 (2012), pp. 159–179.
9. Abdullah M. S., Kimble C., Benest I. and Paige R., "Knowledge-based systems a re-evaluation", Journal Of Knowledge Management, Vol. 10, No. 3 2006, pp. 127-142.
10. Darai D.S., Singh S., Diswas S., "Knowledge Engineering - an overview", International Journal of Computer Science and Information Technologies 1(2010), pp. 230–234.

11. Dostatni E.,: "Design process knowledge management", Journal of Mechanical Engineering and Production Management, Politechnika Poznańska, Nr. 5, 2007, pp. 17-31.

12. Duda J.,: "Rozwój metod projektowania procesów technologicznych obróbki" („Development of methods of machining processes design"), Conference proceedings: XVI Konferencja Innowacje w Zarządzaniu i Inżynierii Produkcji (Innovations in Management and Production Engineering), Zakopane 24-26.02.2013.

13. Zawadzki P., Górski F., Kowalski M., Paszkiewicz R., Hamrol A.,: "System for 3D models and technology process design", Transactions of FAMENA, issue 2, volume 35, 2011.

14. Zawadzki P. Kuczko W., "Pozyskiwanie i implementacja wiedzy w procesie automatycznego projektowania wyrobów wariantowych" („Gathering and implementing knowledge in process of automatic design of variant products"), Conference proceedings: XVII Konferencja Innowacje w Zarządzaniu i Inżynierii Produkcji (Innovations in Management and Production Engineering), Zakopane, 2014. - T2, pp. 296-306.

15. Zawadzki P., Kowalaski M., Wichniarek R., Kliński G.,: "Automatyzacja procesu projektowania rur giętych w oparciu o parametryczny system CAD" („Automation of bent pipes design process on the basis of a parametric CAD system"), Conference proceedings - CAx Innovation, Mechanik. - 2014, issue 2.

MEASURING THE APPEAL OF FASHIONABLE DRESSES IN VIDEO PROGRAM ON MOBILE DEVICES

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ABSTRACT

While "Hunger Games 2: Catching Fire" attracting large audiences, the issue "fashionable dresses in movies" was evoked again. This project aims to explore the sociocultural appeal of fashionable dresses in movies based on Kansei Engineering. Why consumers prefer them to other types of designs, what specific characteristics attract them, and how sociocultural factors have influence on product appeal are the four major issues to be probed in the thesis. The final results will be used for the development of conceptual design proposals. In the aspect of methodology, experts were interviewed and consumers were surveyed with questionnaires to gather the data about their preferences. Preference-based studies are believed to reveal the underlying reasons for the appeal of fashionable dresses in movies. The collected data were analyzed using Quantification Theory Type. This study will determine that the semantic structure of appeal shows the hierarchy of the relationship among appeal factors, the reasons for consumers' preferences, and the specific characteristics of fashionable dresses in movies. In addition, appeal factors will be affected in varying degrees by particular reasons and characteristics. The results also will prove that fashionable dresses in video programs have their own appeal factors, and provide important information for designers and researchers of fashionable dresses in video programs, and also contribute to the field of media communication.

Keywords: Kansei Engineering, Miryoku Engineering, appeal, fashionable dresses in movies, sociocultural, EGM (The Evaluation Grid Method), Quantification Theory Type I

INTRODUCTION

The movie "Hunger Game 2" had become the top-grossing movie in northern America during two weeks since the opening day and also took in over 12 million in Taiwan. Hence, foreign designers feel the great mass fervor and foresee the business of fashionable dress.

Then, the designers cooperated with shopping websites to promote a series of dresses for perking up to the feverish subject of a talk and stimulating sales (TVBS, 2013). From earlier works, such as "The Girl With Dragon Tattoo", "The Devil Wears Prada", to recent ones, such as "Hunger Game 2", The upsurge driven by fashionable dresses has never diminished. This also reflects the value of the trunk stream in society and culture. I hypothesize that the popularity of fashionable dresses is due to certain appeal factors. The factors of appeal that I have explored range from an abstracts of human preferences, such as "dominant", to specific items, such as "a sumptuous coat". I have identified the origin of appeal, from the point of view of people's affections and perceptions that are aroused by their reaction to fashionable dresses.

REVIEW OF THE LITERATURE

Fashionable dresses

Fashion originates from a structure and society, the aim that the communication of fashion in the process of social difference and integration is to satisfy the psychological needs and for modern economical life (Davis, 1994). In addition, fashionable dresses which concrete the latest aesthetics is fashion (Entwiste, 2000); hence, according to the above-mentioned, the conclusion that fashion is almost the characterization of social culture. Furthermore, a movie is the entrance of fashion, which breaks the boundary between humans and fashion. It means that the function of movies works as a window which let people in the society contact fashion.

Our dressing states that culture is a source which people share value in society from (Carey, 2009). This means that culture has significant influence on the design of fashionable dresses in movies.

Kansei Engineering

"Kansei" is similar to a semiotic system, which is designed to determine human affection and preference to products. Thus, from the viewpoint of Kansei Engineering, which can be used in the study of the design of customer-centred products, a very import issue for developers and designers is the type of feeling that a product evokes in its users. This method of study can be used to develop a system of investigation and analysis of the attraction, cognition, and perception of fashionable dresses, in order to provide support for designers and evaluation groups. For example, Nagamachi (2008) used the method of Kansei Engineering to establish a hierarchy of the values in

a customer's life. Hence, Kansei Engineering studies can also be used to assess dress style and dress design. Subjective evaluation, which is dependent on different semantics, can be analysed through multivariate statistical analysis. The relationship between impression and style characteristics can then be determined and can be used to support the creation of a desired design proposal.

RESEARCH OBJECTIVES

This study explored the appeal of fashionable dresses in movies from the point of view of human emotions. I hypothesize that the popularity of fashionable dresses in video program can be ascribed to the design of a dress plus the influence of media communication. Hence, the critical issues of this study are why the audiences of movies have the will to consume this type of dress and what their motivations are under sociocultural influence. In order to determine the appeal of fashionable dresses in movies and audiences' motivation, I used a preference-based study. The study employed Kansei Engineering as its basic research foundation because it can not only explore the appeal of products based on human's emotions but can also determine the specific design elements that attract consumers. Furthermore, the connection between human emotions and specific design elements can be established through Kansei Engineering. Kansei Engineering is composed of both qualitative and quantitative methods.

RESEARCH METHODS

The study employed both qualitative and quantitative methods to conduct Kansie Engineering. For qualitative research, the evaluation grid method (EGM) was adopted during the phase of in-depth interviews with individual experts. The contents of the interviews were recorded and summarised in the form of hierarchy diagrams (Figures 1 and 2), which were then used as the foundation for the design of a questionnaire. For the quantitative research, the questionnaire was distributed and the data collected were used for statistical analysis, applying Quantification Theory Type I. All of these procedures were conducted according to the theory and processes of Kansei Engineering.

Interviews using the EGM

A consumer's actual behaviour is often very different from the answer given on a general questionnaire. Therefore, a reliable method to capture evaluation items for the determination of product appeal is necessary. In this study, the EGM was used to determine the appeal factors, and a hierarchical diagram of the appeal factors for fashionable dresses

was constructed. Sanui (1996) integrated the repertory grid method into the EGM in two processes. This method is called the "evaluation grid method". The EGM is a deep interview method in which paired comparisons and interpretive structural modelling are used for structural identification. In our study, the EGM was used to capture the appeal factors, and a hierarchical diagram of the appeal factors for a fashionable dresses in movies was built. In order to understand the appeal factors of fashionable dresses video programs, interviews were conducted using the EGM. Six male and three female experts between the ages of 30 and 55 were interviewed. In addition, a comprehensive list of the appeal factors of fashionable dresses in movies was provided for the 9 interviews and the saturation point was attained.

  All of the participants were either experienced managers or designers. A total of 5 popular fashionable movies were selected as the research targets for the interviews. These experts, who had seen all 5 movies, were asked about their preferences for the fashionable dresses in movies.

    The procedures of the EGM are as followings: a total of 120 sample cards, with pictures, containing fashionable dresses from 5 movies, were selected for interview; these 120 sample cards were grouped into three stacks according to the participants' preferences, from high to low; the original evaluation items were obtained by asking the participants about the images and their reasons in grouping them in the three stacks. Each original evaluation item was then processed to form its corresponding "upper-" and "lower-level" concepts. "Upper-level" means that words are more abstract in the hierarchical structure of semantics while "lower-level" means that the words in it are more specific. The original evaluation items, chosen in accordance with the focus of this paper, are "communicable" and "elegant".

Table 1 The ranking from the hierarchical diagram by the number of times the descriptions appeared

Original images	Upper Level (reasons)	Lower Level (specific attributes)
Communicable 13	Glamorous 23	The black and sleeveless dress 29
Elegant　11	Personalized 17	Black and grey studded ensemble 27
Stratified 7	Empathetic 15	Clothing characters communicate some things about their personality 22
Unique 7	Dominant 14	An icon in the world of fashion 22

| Sexy 6 | Authoritative 14 | A well-known brand without exposing the tags in clothes and shoes 19 |
| Chic 4 | Creative | A knee length black boots 17 |

Design of the questionnaire

In order to measure the weights of the attributes and their importance in fashionable dresses in movies, the strongest three criteria that determine the attractiveness of fashionable dresses in movies, were chosen from the original evaluation items using the EGM. These are "communicable", and "elegant". The upper-level reasons were also determined using these data, as shown in Table II. In order to quantify the range of items and to give a score for the appeal factors of fashionable dresses in movies, we created questionnaires using the attribute and categories as shown in Table III.

Table 2 The best two "original images" selected from the hierarchical diagram by the number of times they appeared

Classified	Original images	Reasons (upper level)
First	Communicable 13	Dominant 22
		Authoritative 17
		Empathic 15
Second	Elegant 11	Qualitative 19
		Sophisticated 17
		Classic 14

Table 3 The setting of the attribute items and categories

Original evaluation item	Upper-level	Lower-level
Communicable	Empathetic	Clothing characters communicate some things about their personality

The following are the examples of the questions in the survey questionnaire:

(1) How do you rate the importance of "communicable" with the following items: "dominant", "authoritative", "empathic", "catching" and "flashy"? (Please evaluate them by the importance, scoring the most important as "5" and the least important as "1".)

(2) In the aspect of "communicable", to which trait do you feel "dominant" should be applied? (Please choose one from the following categories: "a sumptuous coat", "golden color", "an icon in the world of fashion" and "golden gauz".)

The analysis of questionnaire survey

This study adopted the Quantification Type I Method as a tool to analyse the importance of the appeal factors of fashionable dresses in movies. In addition, upper-l and lower-level items were measured and quantified using the importance-levels from the original evaluation. Using multiple linear regression methods, Hayashi's (1950) Quantification Theory Type I can statistically predict the relationship between a response value and the categorical values. Moreover, in product design, Hayashi's Quantification Theory Type I can also be used to evaluate the weights of the factors of users' preferences (Iwabuchi et al., 2001; Sugiyama et al., 1996). The statistical method can be widely applied to research analysis especially for Kansei Engineering. Nagamachi (2008) introduced that Quantification Theory Type I is an excellent technique to depict the relationships between the design elements and Kansei classifications. The technique of Quantification Theory Type I was transferred to a type of mathematic formula and was executed through Excel Macro for statistical analysis.

A total of 223 questionnaires were distributed. Among these, 185 were returned and 157 were valid for analysis (giving a valid return rate of 70.4 per cent). Among these valid respondents, there were 73 males and 84 females, with the ages ranging from 25 to 50.

ANALYSIS AND RESULTS

The hierarchical diagram of fashionable dresses in movies

We created the evaluation structure from answers given by the 6 experts who participated in the interviews using the EGM. Figure 1 shows the hierarchical diagram of the preferences of one participant. In Figure 2, the numbers on the right side of the words indicate the number of times that the same opinion appeared. For example, in the original evaluation item, "communicable 13" means that the word "communicable" was listed ten times from 13 participants. The appeal factors of fashionable dresses in movies were determined according to the preference interviews and using the EGM. Table I also shows the statistical results of "the ranking from the hierarchical diagram by the number of times the descriptions appeared.

Dominant			A Sumptuous Coat
Empathic	→ Communicable →		Golden Color
			A Purposeful and sadistic role
Sophisticated			Stockings and Berets
Classic	→ Elegant →		A Low rise, with a zipper and Button
			The Studded Belt
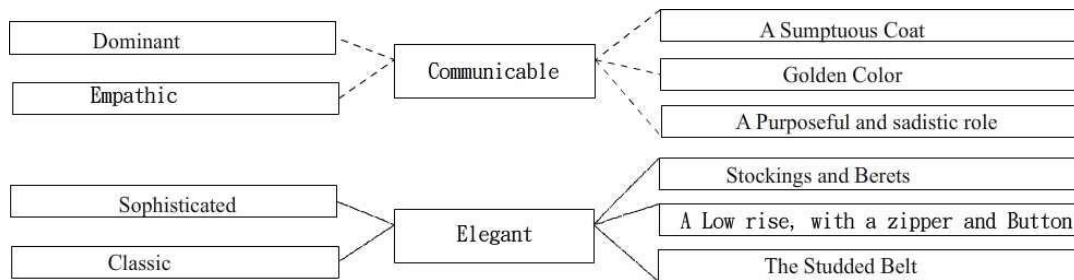
Figure 1

Weighting the appeal of the "communicable" factor

The following statistical analysis is based on the results of the questionnaire survey. The first appeal factor classified was "communicable", which included "dominant", "authoritative", "empathic", "flashy" ,and "catching", in the upper-level assessment. A fashionable dress in movies was classified as "easy and convenient" if it gave the players this impression by choosing one of the five above-mentioned descriptions. In this study, the coefficient of determination (R2¼0.691), which was determined based on the results of the Quantification Type I, indicates standard reliability for our survey instrument. The appeal factor, "communicable", was most affected by "dominant", with the highest partial correlation coefficient. The categories included were: "a sumptuous", "golden color", "and "an icon in the world of fashion". Table IV shows the description statistics for each item. According to the category scores from Table IV, "an icon in the world of fashion" had stronger effect on "showy" than the other categories. In addition, "a sumptuous" had a stronger negative effect on "outstanding" than the others did.

Table 4 The category scores for the factor of "Communicable"

Items	Categories	Category Scores	Partial Correlation Coefficients
Dominant	A Sumptuous Coat	-0.192	
	Golden Color	-0.013	*0.709
	An icon in the world of fashion	0.079	
Authoritative	Golden Gauze	-0.043	0.566
	A well-known brand without exposing the tags in the clothes and shoes.	0.103	
	A Bright Shoe	-0.076	
Empathetic	Clothing characters communicate some things about their persons	0.018	
	People constantly rave about what she wears every day or on the red carpet	*0.136	0.594
	A purposeful and sadistic role	-0.115	
Catching	Classic Pants	0.087	0.696
	A Distinguished Suit	0.027	
	A Generous wool Sweater	0.102	
Flashy	A Bright Coat	-0.100	0.694
	A Hat with a Special Form	0.053	
	Vivid Shoes	0.078	
C		0.860	
R = 0.831			
R Square = 0.691			

Weighting the appeal of the "elegant" factor

The second factor to be classified was "elegant", which included "qualitative e", "sophisticated", "classic", "refined", and "tasteful" in the upper-level assessment. In this study, the coefficient of determination (R2¼0.678), which was determined based on the results of the Quantification Type I, indicates standard reliability for our survey instrument. The highest partial correlation coefficient was "sophisticated" (see Table V), which contributed most to the "elegant" factor. The categories included "stockings and berets", "a

low rise, with zipper and button closure", and "button –down front". As shown in the category scores in Table V, "stockings and berets" had a stronger effect on "sophisticated" than the others. In addition, "a low rise, with zipper and button closure" had a stronger negative effect on this factor than the others did.

Table 5 The category scores for the factor of "Elegant"

Items	Categories	Category Scores	Partial Correlation Coefficients
Qualitative	The Newest Fashionable Trend	0.026	
	The Most Popular Style	0.058	0.517
	The Most Particular Style	-0.07	
Sophisticated	Stockings and Berets	*0.169	
	A Low rise, with a zipper and Button Closure	-0.226	*0.812
	Button-down front	0.022	
Classic	The studded belt	-0.016	0.123
	Present Personal Taste	0.012	
refined	Long dangly necklaces	0.003	
	Have the Superior Feeling	-0.109	0.487
	Show Personal Value	0.121	
tasteful	Show Personal Power	0.055	0.302
	Show Personal Specialty	-0.023	
C		0.698	
R = 0.824			
R Square = 0.678			

DISCUSSION AND CONCLUSION

People prefer fashionable dresses in movies for the additional reasons. Furthermore, "communicable" and "elegant" could explain why people prefer this type of dresses. The results of this study, shown in a hierarchical diagram of preferences, were determined by the EGM.
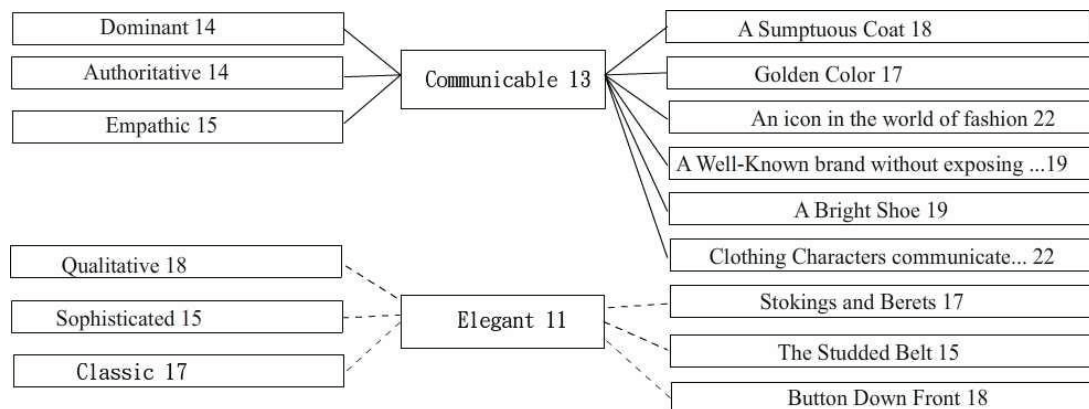
Figure 2

The greatest factors of appeal of fashionable dresses in movies were found to be "communicable" and "elegant", as determined from the evaluation. The consumer that chose an fashionable dresses did so mainly because of one or more of the following 6 characteristics: "dominant", "authoritative", "empathic", "qualitative", "sophisticated", and "classic". Finally, the weights of the features of fashionable dresses were analysed using Quantification Theory Type I. Among these factors, "communicable" had the highest value of R2 (0.691), showing that the test reliability of this factor was the highest.

This research initially explored the appeal of fashionable dresses in movies. The different designs and styles of fashionable dresses in movies attract different groups of fans, indicating the significance of design. In order to explore the impact of the design of fashionable dresses in movies, we used a preference-based study to reveal the appeal of these dresses. The results of the study will assist dress designers and developers in designing attractive fashionable dresses in movies. In addition, the study of fashionable dresses in movies is a potential area for academic research.

REFERENCES

1. Carey, J. W. (2009). Communication as culture. Taylor & Francis, NY: Routlege.

2. Davis, F. (1994). Fashion, culture, and identity. Retrieved from http://www.google.com.tw/books?hl=zh-TW&lr=&id=p-KvoXTYtVoC&oi=fnd&pg=PR9&dq=fashion+culture&ots=1knFYQaREs&sig=SfyfCxylq8O__sEyqI8gOmJDpVk&redir_esc=y#v=onepage&q=fashion%20culture&f=true

3. Entwistle, J. (2000). The Fashioned Body: Fashion, Dress and Modern Social Theory. Cambridge, U.K.:Polity, 2000

4. Hayashi, C. (1950), "On the quantification of qualitative data from the mathematico-statistical point of view", Annals of the Institute of Statistical Mathematics, Vol. 2 No. 1, pp. 35-47.

5. Iwabuchi, C. et al. (2001), Data Management and Analysis by Yourself, Humura Publishing, pp. 180-5.

6. Nagamachi, M. (2008), "Perspectives and the new trend of Kansei/affective Engineering", The TQM Journal, Vol. 20 No. 4, pp. 290-8.

7. Oatley, K. (1999), "Meetings of minds: dialogue, sympathy, and identification in reading fiction", Poetics, Vol. 26 Nos 5-6, pp. 439-54.

8. Sanui, J. (1996), "Visualization of users' requirements: introduction of the evaluation grid method", Proceedings of the 3rd Design & Decision Support Systems in Architecture & Urban Planning Conference, Vol. 1, pp. 365-74.

9. Sugiyama, K. and Novel, K. (1996), The Basic for Survey and Analysis by Excel: A Collection of Tool for Planning and Design, Kaibundo Publishing, Tokyo, pp. 51-62.

CHANGES OF THE SCIENCE, TECHNOLOGY AND INNOVATION (STI) STRATEGY OF KOREA IN VIEW OF NATIONAL INNOVATION SYSTEM (NIS)

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ABSTRACT

The paper is to review changes in Science, Technology and Innovation (STI) strategies of Korea in view of National Innovation System (NIS). Key questions to explore in this study include 1) What are the framework conditions to build STI strategies? 2) How did the Korean government reorganize the structure of the innovation system to implement STI strategies? 3) What are the national programs planned to facilitate the innovation system? 4) What is the nature of innovation strategies of Korea?

To seek answers to these questions, this paper reviews gradual changes in STI strategies and NIS by phases of development in Korea. Innovation strategies in Korea have been established to make the best use of limited resources in the wake of evolving circumstances both internally and externally. The core of the strategies lies in connecting research to innovation. To implement these strategies, national STI programs have been planned to facilitate the role of actors, innovation activities, subsystems and linkages at NIS level. This paper outlines the implementation of innovation strategies of Korea and evolution of NIS with focus on cases of connecting research to innovation.

These cases will help understand that the innovation strategy of Korea goes further than merely responding to issues or demands at hand to take a creative and future-oriented approach. The study is expected to contribute to shedding light on the role of the government and the public sector of Korea in initiating leading investment in innovation.

APPLYING TYPE-II FUZZY INFERENCE SYSTEM FOR MEDICAL DIAGNOSIS

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ABSTRACT

Purpose: *The purpose of this paper is to apply a robust type-II fuzzy inference system (FIS) to assist breast cancer diagnosis. This study utilizes the advantages of type-II fuzzy inference system, which has been proven to be most effective in some situations, to breast cancer diagnosis.*

Design/methodology/approach: *In this paper, the authors apply type-II fuzzy inference system. The measurement of manager's judgments is difficult and vague. In the study, triangular fuzzy numbers (TFS) are used to represent uncertain data. Type-II fuzzy inference system is employed to model vaguely defined relations between TFS.*

Findings: *Type-II FIS is successfully applied in medical diagnosis. The type-II FIS is capable of dealing with complex medical diagnosis problem where various uncertain parameters and incomplete knowledge are involved. Better suitable for revealing experts knowledge and constructing fuzzy models in human tractable form while using type-II fuzzy inference system.*

Practical implications: *Medical diagnosis is a critical topic in hospital. To handle such medical diagnosis, the type-II fuzzy inference system can assist doctor to decision disease. In this study, the breast cancer can be evaluated possibility based on type-II fuzzy inference system.*

Originality/value: *This study is the first attempt to use type-II fuzzy inference system in breast cancer diagnosis. The empirical results of the type-II fuzzy inference system revealed improved performance regarding medical diagnosis.*

INTRODUCTION

The primary goal of this study was to apply type-II fuzzy inference system to deal with breast cancer diagnosis problem. The type-2 fuzzy inference system has been proven to be most effective in some situations (1; 2; 3). The more advantages features of type-2 fuzzy inference system as compared to traditional fuzzy inference system are better description of uncertainty and higher computational power. However, duo to the computational difficulties, type-II fuzzy inference system can not popularly be applied than traditional fuzzy inference system. Moreover, in breast cancer diagnosis, uncertainty arises in the vision and doctor's subjectivism. Therefore, this study firstly attempts to deal with breast cancer diagnosis problem using type-II fuzzy inference system for obtaining more objective decision.

TYPE-II FUZZY INFERENCE SYSTEM

Fig. 1 shows the structure of a type-II fuzzy inference system. The structure of a type-II fuzzy inference system is very similar to the traditional fuzzy inference system 4. Traditional fuzzy inference system only contains defuzzifier. The type-II fuzzy inference system has two outputs which are the type reducer and crisp defuzzified value respectively. This section will briefly introduce the type-II fuzzy sets, rules, and type reduction and defuzzification in following sections.
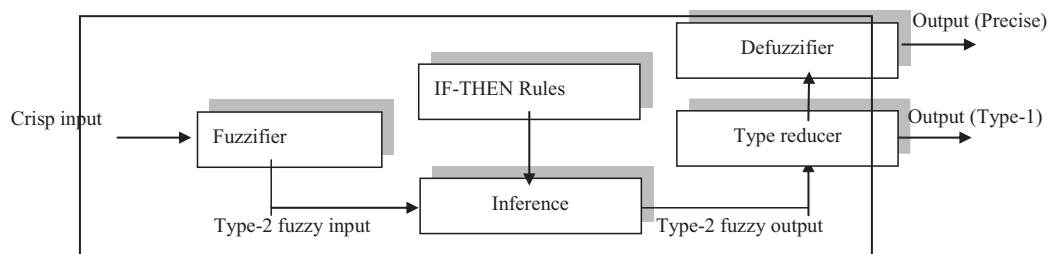
Fig. 1 Structure of type-2 fuzzy inference system. 4

Type-2 fuzzy sets (Fuzzy input)

Fig. 2 shows all the definitions adopted for type-II fuzzy sets. This particular set, is characterized build a type-II membership function $\mu_A(x,u)$, where $x \in X$ and $u \in J_x \subseteq [0, 1]$, i.e.

$$A = \int_{x \in X} \int_{u \in J_x} \frac{\mu_A(x,u,v)}{(x,u,v)}, J_x \subseteq [0,1] \qquad (1)$$

In which $0 \leq \mu_A(x,u) + \mu_A(x,v) \leq 1$.

Uncertainty in the primary memberships of a type-II fuzzy set, A, consists of a bounded region that is called the Footprint of Uncertainty (*FOU*) 5. FOU characterizes type-2 fuzzy sets and is defined as the Union of all primary membership:

$$FOU(A) = \bigcup_{x \in X} J_x \tag{2}$$

FOU is associated with the concepts of lower and upper membership functions and models the uncertainties in the shape and position of the traditional fuzzy set; its uniform shading denotes interval sets for the secondary membership functions and represents the entire interval type-II fuzzy set $\mu_A(x,u)$. The upper and lower membership functions 6 are in fact two traditional membership functions that are bounds for the FOU of a type-2 fuzzy set A. $\overline{\mu_A}(x)$ is the upper membership function (UMF) and is associated with the upper bound $FOU(A)$ It is also denoted as:

$$\overline{\mu_A}(x) \equiv \overline{FOU(A)}, \forall x \in X \tag{3}$$

$$\overline{v_A}(x) \equiv \overline{NFOU(A)} = 1 - \overline{FOU(A)} - \overline{\pi_A}(x), \forall x \in X$$

$$\overline{\pi_A}(x) \equiv \overline{HFOU(A)}, \forall x \in X = 1 - \overline{FOU(A)} - (1 - \overline{FOU(A)}^{\alpha})^{1/\alpha}, \forall x \in X$$

$\underline{\mu_A}(x)$ is the is the lower membership function (LMF) and is associated with the upper bound $FOU(A)$ It is also denoted

$$\underline{\mu_A}(x) \equiv \underline{FOU(A)}, \forall x \in X \tag{4}$$

$$\underline{v_A}(x) \equiv \underline{FOU(A)}, \forall x \in X$$

$$\underline{\pi_A}(x) \equiv \underline{HFOU(A)}, \forall x \in X = 1 - \underline{FOU(A)} - (1 - \underline{FOU(A)}^{\alpha})^{1/\alpha}, \forall x \in X$$
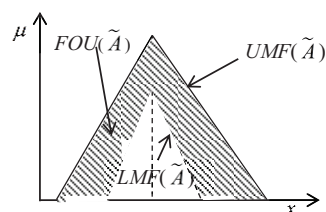
Fig. 2. FOU(Shaded), LMF(dashed) and UMF(solid) for Type-2 fuzzy sets A.3

Rules

The nature of membership function is the real distinction between traditional fuzzy and type-2 rules. In traditional fuzzy rules, we generally have "IF-THEN" rules, where the lth rule has the form "R^l: IF x_1 is F_1^l and x_2 is F_2^l and…and x_p is F_p^l, THEN y is G^l", where : x_is are inputs; F_i^ls are antecedent sets ($i=1,…,p$); y is the output; and G^ls are consequent sets. The lth rule in a type-II rule has the form "R^l: IF x_1 is F_1^l and x_2 is F_2^l and…and x_p is F_p^l, THEN y is G^l ". We can note that the structure of this type-II rule is exactly the same of type-1 rule; the only difference is in the nature of membership functions.

Type reduction and defuzzification

The output of the inference engine is a type-II fuzzy set and it must be type-reduced. The center of sets is the most commonly used type-reduction method which can be expressed as:

$$Y_{\cos}(Y^1,...,Y^M,F^1,...,F^M)=[y_l,y_r]= \int_{y^1\in[y_l^1,y_r^1]} \cdots \int_{y^M\in[y_l^M,y_r^M]} \int_{f^1\in[\underline{f^1},\overline{f^1}]} \cdots \int_{f^M\in[\underline{f^M},\overline{f^M}]}$$

$$\times \frac{1}{(\sum_{i=1}^M f^i y^i / \sum_{i=1}^M f^i)} \tag{5}$$

where Y_{cos} is an interval set determined by two end points, y_l and y_r; $f^i\in F^i =[\underline{f^M},\overline{f^M}]$; $y^i\in Y^i=[y_l^i,y_r^i]$, and Y^i is the centroid of the type-2 interval consequent set G^i; and, $i=1,…, M$. Because Y_{cos} is an interval set, we can defuzzify it using the average y_l and y_r; hence, the defuzzified output of an interval type-2 fuzzy inference system is

$$f(x) = \frac{y_l + y_r}{2} \quad . \tag{6}$$

The breast cancer diagnosis problems

The identification of micro-calcifications can be used in the effective detection of breast cancer which has been verified in medical field. The procedure of mammography, a specific type of X-ray radiograph, can digitally capture the contrasting imageries of both micro-calcifications as well as normal breast tissues. However, different examiners of the same digitized images may arrive at divergent diagnoses due to the varying experience and background of each examiner as well as his/her own subjectivity. In this study, we discuss with professional physician, and investigate the variables of micro-calcifications to establish the fuzzy decision rules (Table 1). The "H" is high, "M" is median, and "L" is lower. These are type-II membership functions. This study adopts type-II fuzzy inference system as inference engines. In this study the correct rate of type-II fuzzy inference system is 80% which is better than traditional fuzzy inference system.

Table 1 Decision rules of breast cancer diagnosis problems

Variables					Decision
Micro-calcification clusters	Calcification density		Calcification abnormal shape		
H	H			H	4A
				M	4A
				L	3
		M		H	4A
				M	3
				L	4A
		L		H	3
				M	3
				L	3
M	H			H	4A
				M	3
				L	3
		M		H	4A
				M	3
				L	3
		L		H	3
				M	3
				L	3
L	H			H	4A
				M	3
				L	3
		M		H	3
				M	3
				L	3
		L		H	3
				M	3
				L	3

3: means negative (60%)

4A: means positive (60%)

CONCLUSION

In this study, type-II fuzzy inference system is successfully applied in breast cancer diagnosis problems. The type-II fuzzy inference system is capable of dealing with complex breast cancer diagnosis where various uncertain parameters and incomplete knowledge are involved. Better suitable for revealing experts knowledge and constructing fuzzy models in human tractable form while using type-2 fuzzy inference system. Through the type-2 fuzzy inference system, managers can obtain more objective estimated value than traditional fuzzy inference system in medical diagnosis.

REFERENCES

1. Xia X, Liang Q. Cross-layer design for mobile ad hoc networks using interval type-2 fuzzy logic system. *International Journal of Uncertainity, Fuzziness and Knowledge-Based Systems* 2008;**16**:391–407.
2. Hidalgo D, Castillo O, Melin P. Type-1 and type-2 fuzzy inference systems as integration methods in modular neural networks for multimodal biometry and its optimization with genetic algorithm. *Information Sciences* 2009;**179**:2123–2145.
3. Galluzzo M, Cosenza B. Control of the biodegradation of mixed wastes in a continuous bioreactor by a type-2 fuzzy logic controller. *Computers and Chemical Engineering* 2009;**33**:1475–1483.
4. Mendel JM. Fuzzy logic systems for engineering: a tutorial. *Proc. IEEE* 1995;**83**: 345–377.
5. Karnik NN, Mendel JM. Operations on type-2 fuzzy sets. Fuzzy Sets and Systems 2000;**122**: 327–348.
6. Mendel JM, Liang Q. Pictorial comparisons of type-1 and type-2 fuzzy logic systems. *Intelligent Systems and Control* 1999; 280–285.

ANALYSIS ON STRATEGIC HOSPITAL SERVICE QUALITY BASED ON THE PERSPECTIVE OF HOSPITAL MANAGEMENT, GOVERNMENT POLICY MAKER AND ACADEMICIANS IN INDONESIA

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ABSTRACT

Pursuant to the 1945 Constitution of the Republic of Indonesia article 34(3), any citizen has the right to have access for decent health services. Unfortunately, the Indonesian Corruption Watch (ICW) survey in 2010 came up with the conclusion that the healthcare services in Indonesia is far from satisfaction especially for the poor. The main purpose of this research is to analyze attributes that are required by the general hospital to increase the hospital service quality that can fulfill the stakeholders (i.e. hospital management, Ministry of Health as government policy maker and academician) needs and expectations. This research uses qualitative and quantitative study by conducting interviews and distributing questionnaires to the Director of Health Efforts Referral (Bina Upaya Kesehatan Rujukan) of the Ministry of Health, three experts from the Hospital Accreditation Commission (KARS - Komisi Akreditasi Rumah Sakit), nine high-level management officials of the general state hospitals and one academician. We analyzed the resutlting data by using the Entropy method. The conclusion of this research is that the main attributes that are necessary to be implemented by hospital, in a priority order, are personnel with high degree of professional and empathy, reliability and responsive process, policies that can provide assurance to patients on the basis of the latest clinical guidelines and standards, and having adequate infrastructures (i.e. building facilities, medical equipment and hygiene).

Keyword: service quality, hospital service quality, healthcare

INTRODUCTION

Indonesia is a developing country. As a developing country, one of the problems faced by the Indonesian Government is related to the health sector. According to the data from the Global Health Index (http://www.worldlifeexpectancy.com/global-health-comparison-index-indonesia), Indonesia ranks 117 out of 199 countries. This suggests that the level of health in Indonesia is slightly below the intermediate level. Thus, it still requires a lot of effort to attain the health indicators set by the World Health Organization (WHO) in order to achieve the Millennium Development Goals (MDGs) related to health, particularly the 4th, 5th, and 6th goals, i.e. reduce child mortality, improve maternal health, and combat HIV/AIDS, malaria and other diseases.

Among others, poor hospital service is one of the reasons for the low health level in Indonesia. The survey by the ICW on the Citizen Report Cards (CRC) in 2010 on 986 (mostly poor) patients who hold Jamkesnas (National Health Insurance), Jamkesda (Regional Health Insurance), Gakin (Health Assurance for the Poor and the Underprivileged) and SKTM (*Surat Keterangan Tidak Mampu* - the poor) at 19 general hospitals in Jakarta, which consists of 12 state hospitals and 7 private hospitals, generates major findings that 70.5 percent of the patients were complaining. Based on the ICW findings, the complaints are related to (ICW, 2010):

- Poor services by the physicians, nurses, and healthcare personnel
- Inferior hospital facilities (e.g. hygiene of toilets, beds for inpatient care, inpatient rooms, food hygiene, waiting lounge, etc.)
- Inadequate medicine accessibility (e.g. due to limited capacity/stock or drug variety of the hospital pharmacy)
- Troublesome requirement for the patients to provide an advance payment (e.g. because the free medical treatment program has not been fully implemented)
- Exhausting (lengthy and time-consuming) preliminary administration process due to complex hospital bureaucracy.
- Patient rejection (due to, e.g. incomplete requirements administration, inability to provide an advance payment, limited bed capacity, insufficient medical equipment, etc.)

The low quality of the hospital services certainly has a negative effect on the MDGs accomplishment in 2015. The government itself has tried to improve the healthcare quality, e.g. through the Regulation of the Minister of Health of the Republic of Indonesia Number 228/Menkes/SK/III/2008 on The Minimum Service Standards of Hospitals. However, not all organizations comply with these regulations.

In addition, as a means to achieve the MDGs, good quality health services would provide strategic value to healthcare organizations. Good quality service can be used to win the competition in the market. Woodruff stated that customer value is a source to gain competitive advantage (Woodruff, 1997). This is aligned with Clow and Vorhies' proposition which states that good quality care is one of the means to gain competitive advantage (Clow and Vorhies, 1993). Therefore, healthcare organizations must improve their productivity and innovation.

Services are different from products given their particular characteristics which are intangible (cannot be touched and measured as things), heterogeneous (varies depending on the time or the service provider), inseparable (the acts of providing and receiving services cannot be truly separated from each other) and perishable (services not utilized at a certain time cannot be replaced). Healthcare service, however, differs from other services since it has specific characteristics as shown in Table 1.

Table 1 Dissimilar Characteristics of Medical Services to Other Services (Pai and Chary, 2013)

Characteristics	Description
Healthcare is a need service	A customer arrives with some combination of illness, pain, anxiety, fear and under stress
Lack of control	Patients are not in control such that they cannot come and go at will
Surrender confidentiality	Patients relinquish their privacy (and modesty) to clinicians
Healthcare services are labour and skill intensive	There is a variability in performance from one clinician to another
Made-to-order	The needs are to be tailored as patient require a more holistic and customized service
Collaboration	A patient's cooperation both during the encounter (answering questions honestly) and afterwards (taking the prescribed medication) is important for a successful treatment

According to Merriam-Webster Dictionary, quality is defined as "the degree of excellence; superiority of kind and a distinguishing attribute" (Quality, n.d.). Grönroos as cited in Sohail (2003) argued that the quality of services both technical and functional is a key ingredient in the success of service organization. Technical quality in healthcare is defined primarily on the basis of technical accuracy of the diagnosis and procedures; meanwhile, functional quality relates to the manner of delivery of healthcare services (Sohail, 2003). Quality measurement in healthcare is more difficult to define than other services because it is

the customer himself/herself and the quality of his/her life that is being evaluated (Pai and Chary, 2013).

A very popular theory related to service quality is SERVQUAL proposed by Parasuraman et al. (1988). SERVQUAL defined the quality of services that include Tangible, Reliability, Assurance, Responsiveness, and Empathy dimensions, which measures the quality of services by looking at the gap between perceptions and expectations (Parasuraman et al., 1988). Another framework, viz. SERVPERF, was developed by Cronin and Taylor using the same dimensions as SERVQUAL; however, the quality is measured by the perception of consumers only (Cronin and Taylor, 1994). Unfortunately, these frameworks were developed for general purpose; therefore those cannot be simply adapted to the needs of hospital service quality assessment. Hence, this research is formulated to identify and analyze the strategic hospital service quality that is required based on the perspective of hospital management, government policy maker and academicians in Indonesia.

This paper is organized as follows: section 2 explains on the literature review, while the research conceptual model is explained in section 3. The research methodology is discussed in section 4. Then, the results and analysis of this research are subsequently discussed in section 5 and 6. The final section discusses the conclusions and future works of this research.

LITERATURE REVIEW

Service Quality

Service quality has become an important research topic in various industries due to its significant relationship to costs, profitability, customer satisfaction, customer retention, and service guarantee (Sohail, 2003). One of the most profound impacts on service quality and successfully applied on several service fields in the American practice fields was first mentioned by Parasuraman et al., who introduce the SERVQUAL model in their 1985 study (Becser, 2007). Parasuraman et al. defined the SERVQUAL model as a tool aimed at assessing customer perceptions of service quality in service and retailing organizations by involving these dimensions (Parasuraman et al., 1988):

- Tangibles: the physical appearance of the service, equipment, facilities, tools and staff
- Reliability: the ability to perform the promised service in an adequate and reliable manner
- Responsiveness: capacity to solve the customer problems and to serve customers quickly
- Assurance: the knowledge, politeness and reliability of the employees
- Empathy: care, personalized attention given by the organization to the customer

Healthcare Service Quality

In defining healthcare service quality, many researchers derived their dimensions based on the SERVQUAL model that was proven to be a useful instrument in service quality research (Büyüközkan, 2011; Butt and de Run, 2010; Chaniotakis and Lymperopoulos, 2009; Ladhari, 2009; Rashid and Jusoff, 2009). Based on study by Mosadeghrad (2013), quality healthcare is defined as "consistently delighting the patient by providing efficacious, effective and efficient healthcare services according to the latest clinical guidelines and standards, which meet the patient's needs and satisfies providers". Satisfaction and patients fulfillment needs is argued to be the top priority of achieving the hospital service quality. This research also defined the required by the hospitals, i.e. availability, accessibility, acceptability, appropriateness, affordability, competency, timeliness, privacy, confidentiality, empathy, attentiveness, caring, responsiveness, accountability, accuracy, reliability, comprehensiveness, continuity, equity, environment, amenities and facilities (Mosadeghrad, 2013).

Study by Büyüközkan in 2011 defined an evaluation framework of the healthcare service quality model for hospital as well as evaluated the performance of the quality of services provided by four hospitals in Turkey which had good accreditation score. The dimensions being evaluated consisted of tangibles, responsiveness, reliability, assurance, empathy, and professionalism dimension. Each dimension had several criteria and those criteria were to be tested by using fuzzy AHP (Analytical Hierarchy Process). Data were collected from five medical specialists in Turkey. The results showed that the hospital should be more focus on the dimensions of empathy, professionalism, and reliability to improve the quality of health services provided by the hospital (Büyüközkan, 2011). In addition, research from Chaker and Al-Azzab in 2011 determined the elements required in improving patient satisfaction with a case study at Qatar Orthopedic and Sports Medicine Hospital. The elements studied were ease and waiting time in getting service, behavior of personnel, facilities, confidentiality of data and information personnel. The study concluded with the result that patients are satisfied with the services provided by the hospitals; but to continuously improve the quality of services, the hospital management should implement the Balanced Scorecard methodology (Chaker and Al-Azzab, 2011). The summary of the dimensions and the criteria that were used in the before-mentioned works is shown in Table 2.

Table 2 Summary of Healthcare Service Quality Framework

Dimension	Criterion	Definition	Büyüközkan	Parasuraman	Mosadeghrad	Chaker & Al-Azzab
Tangibles	Building layout	Aesthetic, the convenience of the hospital	√	√	√ (Acceptability, Appropriates, Environment)	√
	Equipment	The availability of the equipment in the hospital to provide a satisfactory service	√	√	√ (Facilities)	√
	Hygiene	Hygiene of the hospital and personnel	√	√	√ (Environment)	√
Responsiveness	Timeliness	Ability to provide operations and the promised service on time	√	√	√	√
	Completeness	The availability of all kinds of service at the clinic	√	√	√ (Continuity)	
	Willingness	Willingly assist the patients whenever needed, listen to the patients' complaints and come up with the solutions for the patients' needs	√	√	√	
	Automatic	Provide automated process by exploiting the systems			√ (Accountability)	
Reliability	Accuracy	Accuracy and consistency of the given information (e.g. cost, diagnose of the disease, etc.)	√	√	√	
	Expertise	Authority of staff providing reliability	√		√	
	Image	Creating good vision to public	√		√	
	Security/privacy	Protection of every type of customers' data (e.g. information about patients, etc.)	√		√ (Privacy & confidentiality)	√
Assurance	Cost	Favorable cost of service to the patient	√		√ (Affordability, equity)	
	Courtesy	Courtesy of personnel and their ability to inspire trust and confidence	√	√		
	Compensation	To give guaranty to the patients in case of a problem	√			

Dimension	Criterion	Definition	Büyüközkan	Parasuraman	Mosadeghrad	Chaker & Al-Azzab
Empathy	Caring	Individualized customer service and attention to patients, understanding needs of patients	√	√	√	
	Manner	The attitude of personnel in the service setting	√	√	√ (Amenities)	√
	Communication	Transfer of information between personnel and customer, the degree of interaction, the level of two-way communication	√	√	√	
Professionalism	Skill	Competence and performance of staff	√		√	
	Experience	The accumulation comes into existence step by step	√			
	Innovation	Developing the personnel and hospital services, by trainings, using new technologies	√			
	Physically Accessible	Medical staff easily found by patient to consult or other medical treatment			√	√

Entropy

Data processing in this research is performed using the Entropy technique. This technique is used to determine the weighting of each criterion. Each attribute is assigned a value measured by each alternative to calculate the entropy values and then compared for each criterion. Next, the entropy weight is obtained based on the appraisal matrix information which belongs to the objective weight values (Hsu and Hsu, 2008). The steps undertaken to perform the weighting using the Entropy methods are:

1. Normalizing matrix of the questionnaire result

    As the given value to a criterion goes higher, the criterion becomes more important. Normalization of the matrix values is performed by subtracting all the criteria with the highest value.

2. The value obtained in step 1 is divided by the total value of all the criteria. The formula used is as follows:

$$a_{ij} = \frac{k_{ij}}{\sum_{i=1}^{m} \sum_{i=1}^{n} k_{ij}}$$

    for m > 1, i = 1, ..., n; j = 1, ..., m, where n is the number of decision-makers, and m is the number of criteria.

3. Determining the value of entropy, dispersion and the weight of each criterion. The formula being used to determine the entropy is as follows:

$$E_i = \left[\frac{-1}{\ln(n)}\right] \sum_{j=1}^{n} [a_{ij} \ln(a_{ij})]$$

Dispersion of each criterion can be calculated using the following formula:

$$D_i = 1 - E_i$$

Weighting of each criterion can be calculated using the following formula:

$$W_i = \frac{D_i}{\sum D_i}$$

CONCEPTUAL MODEL OF RESEARCH

Summing up the dimensions and criteria in the literature review and classifying those dimensions and criteria to the group of Human Resources (People), Processes, Infrastructure and Policy, this research proposes a research model as shown in Figure 1. Each sub-criterion will be made in accordance with the definition statement on the questionnaire that will be distributed to the hospital management, government policy makers and academicians.

The group dimension readiness, i.e. the people, process, technology and policy are most required when management and policy makers want to improve their organization's performance. The people dimension means that the organization should be supported by medical and non-medical personnel who both are professional and have good attitude. The process dimension indicates that the organization should have high response level and be reliable to deliver the promised services. The infrastructure dimension should be supported by adequate building and equipment. Lastly, the policy dimension should give assurance for all the promised services. The detailed of healthcare service quality evaluation criteria can be seen in Table 3.
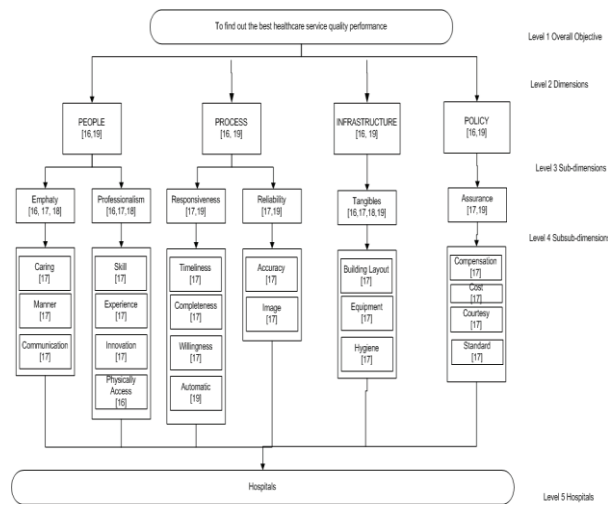
Figure 1 The Evaluation Framework of the Healthcare Service Quality Model

METHODOLOGY

Data Collecting Procedure

This research is a quantitative research using a survey technique. The survey instrument or questionnaire is developed based on the group criteria and the criteria to evaluate the quality of healthcare in general hospitals as shown in Figure 1. Before the questionnaire is being distributed, the questionnaire is tested to identify errors and ambiguity of each statement. This questionnaire is tested by four academicians involved in this research, i.e. three lecturers from the Faculty of Computer Science and one lecturer from the Faculty of Public Health Universitas Indonesia.

Then, the questionnaire is being distributed directly to the management personnel of the two general state hospitals (one central hospital and one regional hospital), a high-level official of the Ministry of Health, experts of the Hospital Accreditation Commission, and a lecturer of the Faculty of Public Health Universitas Indonesia. Those respondents are chosen for they are involved in the policy-making of the strategic service quality indispensable by hospitals that is expected to be adapted to the conditions in Indonesia.

Instruments

In the questionnaire, there are 20 statements, each of which should be scored by the respondents for its importance. For each statement, a Likert scale of 1 to 5 is provided to rate each sub-dimension. Scale 1 is used to express a very unimportant sub-dimension, scale 2 is used to express an unimportant sub-dimension, scale 3 is used to express a neutral sub-dimension, scale 4 is used to express an important sub-dimension, and scale 5 is used to express a very important sub-dimension. The bigger the scale number chosen by the respondents indicate a higher level of respondents' agreement for the importance of the

selected sub-dimension to be implemented in the hospital in order to increase hospital service quality.

RESULTS

Respondent Demographics

Data is collected by distributing questionnaires to the management personnel of a central general state hospital, i.e. the Head of Health Information Management Installation, the Deputy Chief of Emergency Nursing, the Head of Hospital Management Information System, and the Deputy Chief of General Inpatient section A, and a district general state hospital, i.e. the Deputy Director of Services, the Head of Medical Record Sub Division, the Head of the Emergency Unit, and two Heads of Inpatient Rooms), 3 experts from the Hospital Accreditation Commission, a high-level official, i.e. the Director of Health Efforts Referral of the Ministry of Health, and a lecturer at the Faculty of Public Health Universitas Indonesia specialized in the Hospital Administration study.

Measurement with Entrophy

Data processing in this research is performed using the Entropy technique to determine the weighting of each criterion. By the end of September 2013, the number of successful data obtained is 14 questionnaires, being completely filled out by the above-mentioned respondents. The steps undertaken to perform the weighting using the Entropy methods are:

1. Normalize the matrix of the questionnaire result (Table 4)
2. Divide the value obtained in step 1 by the total value of all the criteria (Table 5)
3. Determine the value of entropy, dispersion and the weight of each criterion (Table 6)

Table 3 Healthcare Service Quality Evaluation Criteria and Criteria Group

Dimension	Criteria	Sub Criteria	Definition	Ref
HUMAN RESOURCE	Empathy	Caring	Individualized customer service and attention to patients, understanding needs of patients	1,2,3,4
		Manner	The attitude of health workers and their ability to inspire trust and confidence	1,2,3,4
		Communication	Transfer of information between health workers and customer, the degree of interaction, the level of two-way communication	1,2,3,4
	Professionalism	Skill	Competence and performance of health workers	1,2,3,4
		Experience	The accumulation comes into existence step by step	1,2,3,4
		Innovation	Developing the personnel and hospital services, by trainings, using new technologies	2
		Physically accessible	Medical personnel is easily encountered by patients in consultation or other medical treatment	1,4
PROCESS	Responsiveness	Timeliness	Ability to provide operations and the promised service on time	1,2,3,4
		Completeness	The availability of all kind of services at the hospital	1,2,3,4
		Willingness	Helping the patients willingly whenever help is needed, listening the patients' complaints and come up with solutions through the needs of customers	1,2,3,4
		Automatic	Provides automated process by exploiting a system	1,4

Dimension	Criteria	Sub Criteria	Definition	Ref
	Reliability	Accuracy	Accuracy and consistency of the given information (e.g. cost, diagnose of the disease, etc.)	1,2,3,4
		Image	Creating good vision to public	1,2,3,4
INFRASTRUCTURE	Tangible	Building Layout	Aesthetic, being convenient of the hospital	1,2,3,4
		Equipment	The availability of equipment in the hospital to provide a satisfactory service	1,2,3,4
		Hygiene	Hygiene of the hospital and personnel	1,2,3,4
POLICY	Assurance	Cost	Favorable cost of service to patient	1,2,4
		Courtesy	Courtesy of personnel and their ability to inspire trust and confidence	1,2,3,4
		Compensation	To give guaranty to the patients in case of a problem	1,2,3,4
		Standard	Comply with applicable standards for personnel, processes and infrastructure that are used (e.g. implementing ISO or perform hospital accreditation of the Ministry of Health)	1

Table 4 Normalization Matrix of the Questionnaire Results

Criteria	R1	R2	R3	R4	R5	R6	R7	R8	R9	R1	R1	R1	R1	R14	Total
Caring	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	-1
Manner	-1	-1	0	-1	0	-1	0	-1	0	0	-1	-1	0	0	-7
Communication	0	0	0	0	-1	0	0	0	0	0	-1	-1	-1	0	-4
Skill	0	-1	0	0	-1	-1	0	0	0	0	0	0	0	0	-3
Experience	-1	0	0	-1	0	0	0	0	-1	-1	-1	0	-1	0	-6
Innovation	-1	0	0	-1	-1	-1	0	0	-1	0	0	0	0	0	-5
Physically	0	-1	0	0	-1	-1	0	0	-1	-1	-1	-1	0	0	-7
Timeliness	0	0	0	0	0	-1	0	0	-1	0	0	-2	-1	0	-5
Completeness	-1	-2	0	-1	-2	-2	0	-1	-1	-1	0	-1	-1	0	-13
Willingness	0	-1	0	-1	-1	0	0	0	-1	0	-1	-1	-1	0	-7
Automatic	-1	0	0	-1	-2	0	0	0	0	0	-1	0	0	0	-5
Accuracy	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	-1
Image	-1	0	0	-1	-1	-1	0	0	-1	0	-1	0	-1	0	-7
Building Layout	-1	-1	0	-1	-2	-1	0	-1	0	0	-1	-1	0	0	-9
Medical	-1	-1	0	-1	-2	0	0	-1	0	0	-1	0	-1	0	-8
Hygiene	0	-1	0	0	-1	0	0	0	0	0	-1	0	0	0	-3
Compensation	-1	-2	-3	-1	-1	-1	0	-1	-1	-1	-2	-2	-2	-1	-19
Cost	0	-1	0	-1	0	-2	0	-1	-1	-1	-1	-1	-1	0	-10
Courtesy	-1	-1	0	0	0	-1	0	0	-1	0	0	-1	0	0	-5
Standard	0	-1	0	0	0	0	0	0	-1	-1	-1	-2	-2	0	-8
Total	-11	-14	-3	-11	-16	-14	0	-6	-11	-6	-14	-14	-12	-1	-133

Table 5 Normalization Value Divided by All Criteria Total Value

Criteria	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14
	a_{m1}	a_{m2}	a_{m3}	a_{m4}	a_{m5}	a_{m6}	a_{m7}	a_{m8}	a_{m9}	a_{m10}	a_{m11}	a_{m12}	a_{m13}	a_{m14}
Caring	0	0	0	0	0	0,00	0	0	0	0	0	0	0	0
Manner	0,0075187 97	0,007518 8	0	0,0075 188	0	0,00 7518 8	0	0,007 5188	0	0	0,00 7518 8	0,00 7518 8	0	0
Communica	0	0	0	0	0,00	0	0	0	0	0	0,00	0,00	0,00	0
Skill	0	0,00 7518	0	0	0,00 7518	0,00 7518	0	0	0	0	0	0	0	0
Experience	0,007 5187 97	0	0	0,0075 188	0	0	0	0	0,00 7518 8	0,00 7518 8	0,00 7518 8	0	0,00 7518 8	0

S4-11

Criteria	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14
	a_{m1}	a_{m2}	a_{m3}	a_{m4}	a_{m5}	a_{m6}	a_{m7}	a_{m8}	a_{m9}	a_{m10}	a_{m11}	a_{m12}	a_{m13}	a_{m14}
Innovation	0,0075187 97	0	0	0,0075 188	0,00 7518 8	0,00 7518 8	0	0	0,00 7518 8	0	0	0	0	0
Physically accessible	0	0,00 7518 8	0	0	0,00 7518 8	0,00 7518 8	0	0	0,00 7518 8	0,00 7518 8	0,00 7518 8	0,00 7518 8	0	0
Timeliness	0	0	0	0	0	0,00	0	0	0,00	0	0	0,01	0,00	0
Completeness	0,0075187 97	0,01 5037 59	0	0,0075 188	0,01 5037 59	0,01 5037 59	0	0,007 5188	0,00 7518 8	0,00 7518 8	0	0,00 7518 8	0,00 7518 8	0
Willingness	0	0,00 7518	0	0,0075 188	0,00 7518	0	0	0	0,00 7518	0	0,00 7518	0,00 7518	0,00 7518	0
Automatic	0,007	0	0	0,0075	0,01	0	0	0	0	0	0,00	0	0	0
Accuracy	0,0075187 97	0	0	0	0	0	0	0	0	0	0	0	0	0
Image	0,0075187	0	0	0,0075 188	0,00 7518	0,00 7518	0	0	0,00 7518	0	0,00 7518	0	0,00 7518	0
Layout	0,007	0,00	0	0,0075	0,01	0,00	0	0,007	0	0	0,00	0,00	0	0
Equipment	0,007	0,00	0	0,0075	0,01	0	0	0,007	0	0	0,00	0	0,00	0
Hygiene	0	0,00	0	0	0,00	0	0	0	0	0	0,00	0	0	0
Compensati	0,007	0,01	0,02	0,0075	0,00	0,00	0	0,007	0,00	0,00	0,01	0,01	0,01	0,00
Cost	0	0,00	0	0,0075	0	0,01	0	0,007	0,00	0,00	0,00	0,00	0,00	0
Courtesy	0,007	0,00	0	0	0	0,00	0	0	0,00	0	0	0,00	0	0
Standard	0	0,00	0	0	0	0	0	0	0,00	0,00	0,00	0,01	0,01	0

Table 6 Data Processing Result of the Strategic Hospital Service Quality Evaluation

Dimension	Criteria	Sub criteria	Sub Criteria Weight	Criteria Weight	Dimension Weight
Human Resources	Professionalism	Skill	0,05261485	0,203574	0,359123
		Innovation	0,05108474		
		Experience	0,05031969		
		Physically accessible	0,04955464		
	Empathy	Caring	0,05414495	0,155549	
		Communication	0,0518498		
		Manner	0,04955464		
Process	Responsiveness	Timeliness	0,05130162	0,197773	0,301472
		Automatic	0,05130162		
		Willingness	0,04955464		
		Completeness	0,04561495		
	Reliability	Accuracy	0,05414495	0,1037	
		Image	0,04955464		
Policy	Assurance	Courtesy	0,05108474	0,189542	0,189542
		Standard	0,04922334		
		Cost	0,04747636		
		Compensation	0,04175712		

Dimension	Criteria	Sub criteria	Sub Criteria Weight	Criteria Weight	Dimension Weight
Infrastructure	Tangible	Hygiene	0,05261485	0,149863	0,149863
		Equipment	0,04900646		
		Building Layout	0,04824141		

DISCUSSION

Based on the result in Table 5, it can be concluded that the dimensions that determine the hospital service quality are health personnel, business processes, policies and infrastructures. These results indicate that hospital urgently needs professional health personnel who possess high empathy to the patients (e.g. caring, communicative and well-mannered). A professional health personnel indicates that they should have excellent skill, conducting continuous innovation in accordance with the latest technology and health sciences developments, have sufficient experiences and accessible at any time whenever needed by the patient.

In addition, hospitals must clearly define, formulate and disseminate their business processes to all health personnel who support the operational activities of the hospital. These rules and procedures are required to increase the responsiveness and reliability of the hospitals to accommodate all the needs of the hospital operations. Hospital's responsiveness means the hospital is: able to deliver the promised services on time that is supported by the hospital information system which could make the process more effective and efficient, willing to help patients whenever needed, and having all the required services available. With the accuracy of data and information resulting from the hospital information system, the hospital image would be improved.

The third dimension that must be implemented by hospitals to improve their service quality is policy. The policy dimension includes guarantees in accordance with the applicable standards in Indonesia, the principle of decency so as to increase the patients' confidence, provide affordable services for all patients as well as the compensation or warranty given to the patients whenever problems arise. Finally, the infrastructure dimension also plays an important role in improving hospital service quality and this dimension should also be measured. Sub-criteria that include in this dimension, i.e. the existence of a hygienic infrastructure including buildings, medical equipment, and health personnel, the availability of medical equipment (the capacity of room and bed, surgical instruments, medicines, etc.) as well as the building layout that can satisfy the aesthetics and comfort concept (e.g. easily found symbols and signs to provide clear direction to the patient).

Based on this research result, a significant implication for the Ministry of Health, as Indonesian health policy maker, and the hospital management in Indonesia, is that they should put more attention to improve the skill and competence of the medical and non-medical (i.e.

administrative) staff, particularly those who are located in the hinterlands. Subsequently, with respect to hospitals, they should be equipped with hospital information system that is integrated with other medical equipment and applications in order to provide quick response and accurate information to the patients. The system is likely to be successfully implemented only if the Ministry of Health defines policy for standards in implementing hospital information system that apply to all hospitals in Indonesia. At last, hospitals should also be supported with sufficient infrastructure in order to deliver excellent customer experiences that would imply customer satisfaction and retention. This, therefore, encourages hospitals to be able to prepare their investment strategies both in medical and non-medical technology.

CONCLUSION AND FUTURE WORK

Based on the results of the questionnaires, hospital service quality that needs to be implemented by hospitals in a priority order are the support of the professional and well-mannered human resources, responsive business processes as well as responsiveness in following the development of science and technology, and measurable policies and adequate infrastructures. By utilizing hospital information system, the hospitals can support their business processes responsively, efficiently and effectively. It can also help the hospitals to provide data/information in an accurate and integrated manner as well as to support the implementation of the Patient Safety Act in which patients are handled with adequate data.

Given this research scope, the future works are to further identify service quality from the patients' perspective to be compared with the results of this research. The comparison could be used to show whether there are discrepancies between those requirements. In addition, critical success factors that should be considered by the hospital in implementing hospital information system can be conducted. Finally, in order to provide guidance to the hospital management, high level enterprise architecture for the hospital primary services (i.e. outpatient, inpatient and emergency unit services) should be defined.

ACKNOWLEDGMENT

REFERENCES

1. Becser, N. (2007), "Improving Service Quality in Retail Trade – The Premises of A Potential Measurement Model and A Decision Support System Based on IT", *Ph.D. thesis*, Corvinus University of Budapest.

2. Butt, M. M., and de Run, E. C. (2010), "Private Healthcare Quality: Applying A SERVQUAL Model", *International Journal of Health Care Quality Assurance,* Vol. 23 No. 7, pp. 658-673.

3. Büyüközkan. (2011), "Strategic Analysis of Healthcare Service Quality using Fuzzy AHP Methodology", *Expert System with Applications: An International Journal,* Vol. 38 No.8, pp. 9407-9424.

4. Chaker, M., and Al-Azzab, N. (2011), "Patient Satisfaction in Qatar Orthopedic and Sports Medicine Hospital (ASPITAR)", *International Journal of Business and Social Science,* Vol. 2 No.7, pp. 69-78.

5. Chaniotakis, I.E., and Lymperopoulos, C. (2009), "Service Quality Effect on Satisfaction and Word of Mouth in the Health Care Industry", *Managing Service Quality,* Vol. 19 No. 2, pp. 229 – 242.

6. Clow, K. E., and Vorhies, D. W. (1993), "Building A Competitive Advantage For Service Firms: Measurement of Consumer Expectations Of Service Quality", *Journal Of Services Marketing*, Vol. 7 No. 1, pp. 22-32.

7. Cronin, J. J., and Taylor, S. A. (1994), "SERVPERF versus SERVQUAL: Reconciling Performance-Based and Perceptions-Minus-Expectations Measurement of Service Quality", *Journal of Marketing,* Vol. 58 No. 1, pp. 125-131.

8. Hsu, P.F., and Hsu, M.G. (2008), "Optimizing the Information Outsourcing Practices of Primary Care Medical Organizations Using Entrophy and TOPSIS", *Quality and Quantity,* Vol. 42, pp. 181-201.

9. ICW. (2010), "Survei ICW 2010: Pelayanan Rumah Sakit di Jakarta, Tidak Pro Orang Miskin", available at: http://www.antikorupsi.org/id/content/survei-icw-2010-pelayanan-rumah-sakit-di-jakarta-tidak-pro-orang-miskin (accessed 7 March 2014).

10. Ladhari, R. (2009), "A Review of Twenty Years Of SERVQUAL Research", *International Journal of Quality and Service Sciences,* Vol. 1 No. 2, pp.172-198.

11. Mosadeghrad. (2013), "Healthcare service quality: towards a broad definition", *International Journal of Healthcare Quality Assurance,* Vol. 26 No.3, pp. 203-219.

12. Pai, Y.P, and Chary, S.T. (2013), "Dimensions of Hospital Service Quality: A Critical Review Perspective of Patients from Global Studies", *International Journal of Healthcare Quality Assurance,* Vol. 26 No. 4, pp. 308-340.

13. Parasuraman, A., Zeitmal, V.A., and Berry, L.L. (1988), "SERVQUAL: A Multiple Item Scale for Measuring Consumer Perceptions of Service Quality"*, Journal of Retailing,* Vol. 64 No. 1, pp. 12-40.

14. Quality. (n.d.), In *Merriam-Webster's online dictionary*, available at: http://www.m-w.com/dictionary/quality (accessed 4 April 2014)

15. Rashid, W.E.W., and Jusoff, H.K. (2009), "Service Quality in Health Care Setting, *International Journal of Health Care Quality Assurance*, Vol. 2 No. 5, pp. 471-482.
16. Sohail, M.S. (2003), "Service Quality in Hospitals: More Favourable Than You Might Think", *Managing Service Quality (Emerald-MCB),* Vol. 13 No. 3, pp. 197-206
17. Woodruff, R.B. (1997), "Customer Value: The Next Source For Competitive Advantage"*, Journal of the Academy of Marketing Science*, Vol. 25 No. 2, pp. 139-153.

SEARCHING LOYALTY BETWEEN POWER AND RELATIONSHIPS: A LATENT CLASS APPROACH

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ABSTRACT

Purpose: This research studies how negotiating power and the quality of relationships influence customer loyalty intention among latent customer classes.

Design/methodology/approach: A tentative model was devised and tested using survey data from 173 respondents from the HoReCa customer of a Finnish brewery, Olvi plc. The analysis was conducted with finite mixture structural equation modeling (FMSEM).

Findings: We found FMSEM to be a powerful tool to reveal latent behavioural classes in the context of industrial management. Moreover, it is important to recognize that at least with the concepts used in this study, one homogeneous behavioural model is insufficient.

Research limitations/implications: Our data consist of the customers of only one brewery.

Practical implications: We suggest that it is important for a seller of industrial products or services to understand that while customers may appear to be a homogeneous group, their customer base comprises heterogeneous subgroups. Hence, it is important to identify customers correctly through their actual behaviour, so as to be capable of maximizing profitability.

Originality/value: This study is important to both practitioners and academics since there is little research on industrial management based on mixture analysis available.

Keywords: Relationships, negotiating power, loyalty, brewing industry, mixture analysis, Finite Mixture Structural Equation Modeling.

Classifications: a. Research paper

INTRODUCTION

Theoretically this research draws from Emerson's (1962) distinguished work concerning sociology in the direction of resource dependency literature (e.g. Pfeffer and Salancik, 1978) and relationship management (e.g. Gadde et al. 2002). Emerson's central message was that a social relation commonly entails mutual dependency between the parties and power is a property of the social relations, not an attribute of the actor. According to Pfeffer and Salancik (1978), resource dependency provides power to the resource owner over the firm that needs those resources. However, Gadde et al. (2002) state that evaluating the efficiency of outsourcing and alliances is difficult, and hence, the first and most logical extension to resource dependency is relationship management.

The purpose of this research is to study how negotiating power and the quality of relationships influence customer loyalty intentions. In addition, the association between negotiating power and quality of the relationships is studied to understand whether there is either a trade-off between negotiating power and quality of the relationships, or whether negotiating power and the quality of relationships increase concurrently. This research setting can also be comprehended as Caplaw's (1956) models concerning coalitions in the triads, even though in this paper we study dyadic relationships, because latent classes can be seen as different types of conceptual power–relationship–loyalty triad variations and hence this study sheds light on the different types of connections in industrial business to business markets.

We devised a tentative model from theoretical literature to address the purposes of this research, and the basic structural equation model (SEM) was tested using survey data from 173 respondents from the hotel, restaurant and catering (HoReCa) industry customers of a Finnish brewery, Olvi plc. We also extended the analysis with FMSEM to reveal latent behavioural customer classes concerning loyalty intentions. In revealing latent behavioural classes, the study enhances the understanding of how business relationships can vary (e.g. Caplow, 1956).

The paper first reviews the theoretical background and presents its tentative model before subsequent sections explain the research methods adopted and present the empirical data with the empirical analysis. The paper then proceeds to a discussion and interpretation of the results of the analysis. The final section includes the study's conclusions, its limitations and suggestions for further research.

THEORETICAL BACKGROUND

This research concentrates on the conceptual triad of negotiating power, quality of the relationship and customer loyalty intentions. However, research data consist of dyadic business relationships which may create some confusion for the reader. Hence, we must re-emphasize that we have studied a conceptual triad with dyadic data. This can be justified because in many cases companies are really able to operate effectively only at the first-tier (dyadic) level of transactions and hence the dyad rather than any extended network must be the basic unit of analysis for an understanding of business transactions (Cox, 2004).

The most surprising results of Caplow's (1956) research were those asserting that the nature of the triadic situation often favours the weak over the strong, and the weak member may be described as the most secure participant in a coalition. However, according to Emerson (1962), power resides implicitly in the other's dependency. Dependency may also mean loyalty, because if one party is dependent upon another, the natural conclusion would be that the dependent party would wish to maintain the relationship. Hence, these two sociological studies suggests that power may increase or decrease loyalty.

Supply chain management literature supports both of these views, because the most commonly cited reason for the limitations associated with outsourcing is the increased dependence on service providers (Bolumole, 2001). The situation is thus slightly peculiar; dependency may reduce willingness to cooperate. To gain a better understanding, we reviewed the work of Pfeffer (2003) which states that the resource dependency view was originally developed to provide an alternative standpoint in inter-organizational relations, and some organizations had more power than others because of the particularities of their interdependence and their position in social space. Hence it is not surprising that Gadde et al. (2002) argue that the first and most logical extension of resource dependency is the use of relationship management.

When referring to customer loyalty intentions, it is important to acknowledge the role of cultural aspects alongside negotiating power and relationships. For example in Western culture most suppliers are essentially opportunistic and hence have little real incentive to tie themselves to one customer unless they are forced to do so (Cox, 1999). It is therefore anticipated that power and dependency will prove important factors in customer loyalty intentions in addition to relationships.

From an economic perspective these concepts are very important for actors in business. It is loyal customers who are generally considered profitable because of their reduced price sensitivity, while price sensitive customers scan the market for cheaper options (Stock, 2005). Negotiating power is built upon factors such as the market situation and can therefore be expected to influence prices of products or services. Good quality relationships, like those

that include routines to handle problem situations for example, are commonly thought to reduce transaction costs.

Turning to the cost perspective, we follow Juntunen (2010) and consider loyalty intentions to be a vertical mode of outsourcing, which means concentrating on transaction costs and disloyalty as the horizontal mode, which means concentrating on input prices. This approach is aligned with that of Thorelli (1986) and Jarillo (1988) who split external costs into two different categories: the price of input and transaction costs. Competition in the market, which obviously reduces negotiating power, can lower the input price. Loyalty, as espoused in long-term contracts, can reduce transaction costs.

The concepts outlined above are combined and presented as a research model (see Figure 1). On the one hand, having strong negotiating power makes it possible to maintain the prices that favour the holder of that power. On the other hand, good relationships may yield lower transaction costs. Negotiating power, the quality of relationships and loyalty intentions are presented as a triangle, because the associations between those concepts form the main research interest in this study.
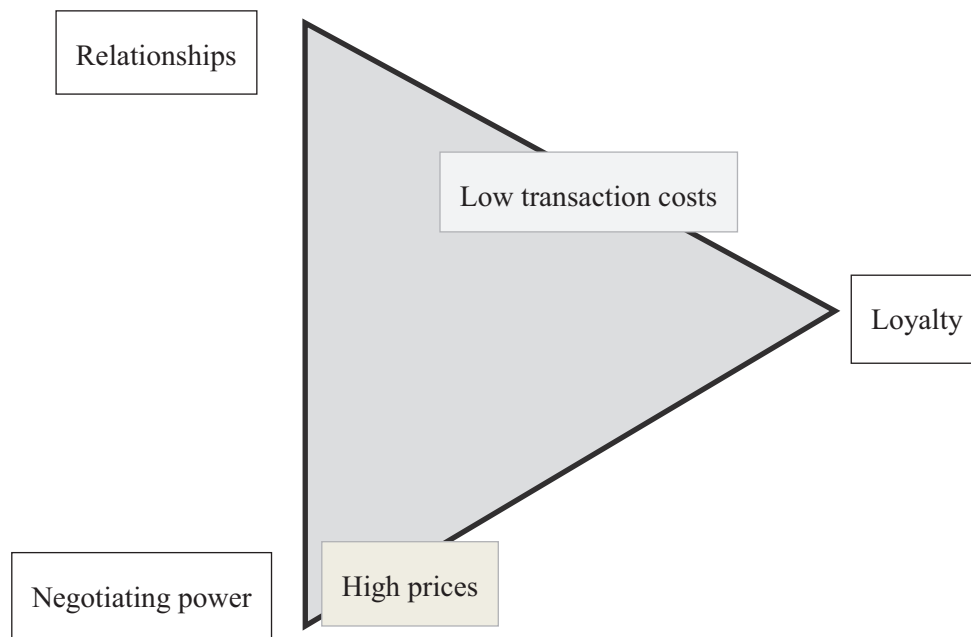
Figure 1: Research model

The concepts in the model can be seen as latent variables (or factors). Our empirical analysis approached negotiating power and the quality of the relationships as independent factors and customer loyalty intentions as a dependent factor. The operational measures were presented in a questionnaire as attitudinal statements based on a 7-point Likert scale and the questions

were anchored with *strongly disagree* and *strongly agree*. The descriptions and the operational measures of the concepts are presented in Table 1.

Table 1: Latent variables and their operational measures

Latent variable	Explanation and operational measures in the questionnaire	Label
Relationships	Refers to the quality of the relationship between the organizations (1 = fully disagree … 7 = fully agree): [Altered from Juntunen et al. 2012]	R
	• We share a long history with Olvi	r1
	• We have effective routines for solving problems with Olvi	r2
	• We have good personal relationships with Olvi	r3
	• We have very casual relationships with Olvi	r4
Negotiating power	Refers to negotiating power with customers (1 = fully disagree … 7 = fully agree)	P
	• Breweries' negotiating power is too strong because of tight competition in the HoReCa business.	p1
	• The terms of the breweries' contracts are too restrictive for _the HoReCa actors	p2
	• Breweries can transfer all their rising costs directly on to their HoReCa customers	p3
Loyalty	Indicate your intentions regarding relationship continuity (1 = fully disagree … 7 = fully agree): [Altered from Vogel et al. 2008]	L
	• We are likely to recommend Olvi to our business partners	l1
	• It is highly probable that we will continue the relationship with Olvi for as long as possible.	l2

METHODOLOGY AND ANALYSIS

Data description and estimation method

The target group of the study consisted of Olvi plc's restaurant customers who are part of the larger HoReCa sector. The study is based on a quantitative approach and empirical data procurement was executed as a Webropol survey in April 2013. Technically, the survey was accomplished with the assistance of the IT environment at the University of Oulu.

The survey was addressed to 645 customers, approximately half of Olvi's registered domestic restaurant customers. It proved impossible to reach a wider number primarily because of Olvi lacking valid email addresses. Larger restaurant chains often centralize their procurement decision making, and consequently the brewery is often not in direct contact with individual restaurant managers. Another factor relating specifically to small privately owned restaurants is that ownership and control change relatively often. This easily leads to a situation where the brewery does not have appropriate email addresses. Nevertheless, the total number of addressees can be considered adequate.

Researchers sent two separate emails and set a response time of one week in each case. We received a total of 173 answers (26.8 %) which may be regarded as satisfactory in light of response rates to similar surveys (e.g. Larson. 2005). Response activity was higher on the first round, which generated 114 answers (65.9 % of the total) and the second round added 59 responses (34.1%).

Despite the relatively good response ratio, 472 addressees (73.2 per cent) did not provide their opinion. The majority of those non-respondents did not respond at all but we received 94 automatic error replies along the lines of, "email address unknown". Excluding those invalid email addresses from the target group, reduces the nonresponse rate to 31.4%. Seven addressees sent messages informing us that they had decided not to participate in any surveys due to time restrictions.

Data analysis
The research model was tested using the operational measures described above (see Figure 2).
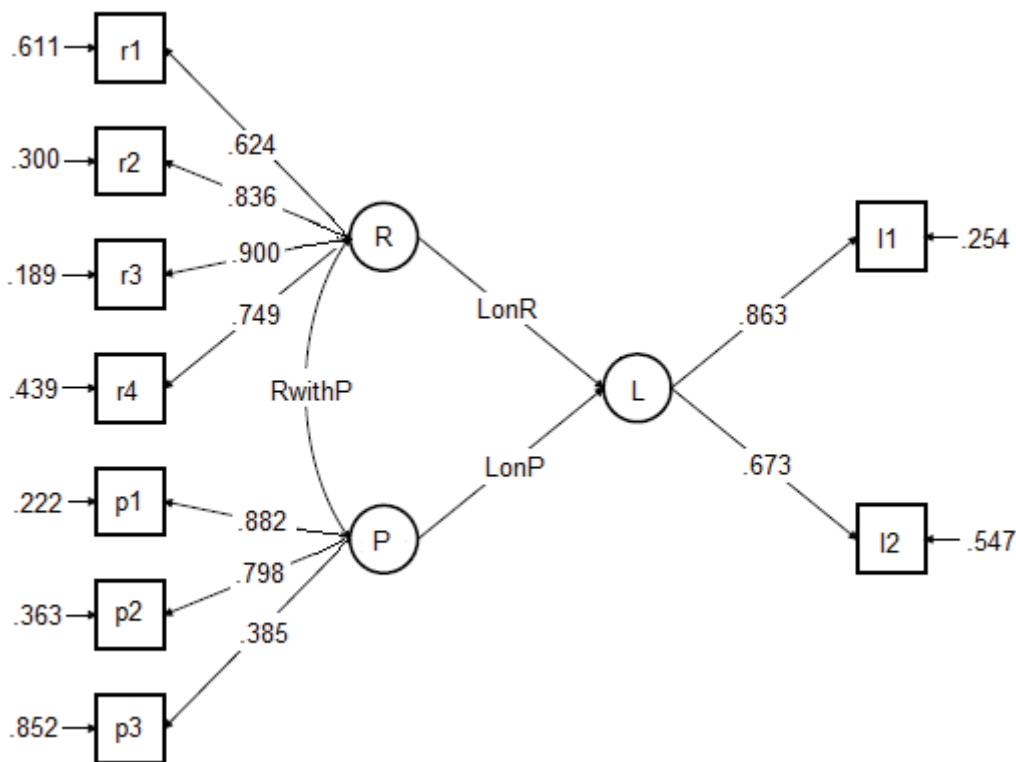
Figure 2: Empirical model

Table 2: Fit indices of structural equation model

Test	Value	P-value	Factor	CR	AVE	Sqrt AVE
Chi-square (degrees of freedom)	39.03 (24)	0.027	R	0.863	0.711	0.843
RMSEA	0.060		P	0.748	0.610	0.781
TLI (NNFI)	0.953		L	0.747	0.545	0.738
CFI	0..969		In SEM, STDYX Standardized LonR 0.752 (p-value, 0.000). RwithP and LonP not statistically significant.			
SRMR	0.047					

The empirical model provides an acceptable statistical fit (see Table 2). According to Browne and Cudeck (1993), an RMSEA value below 0.08 indicates a reasonable fit of the model. Jaccard and Wan (1996) argue that the model's CFI, NFI and GFI value should be above 0.90. Thus, based on the all test values, the model can be considered acceptable. In addition, each latent variable was examined individually and construct reliabilities (CR) with average variance extracted (AVE) suggested good convergent and discriminant validity. However, in SEM, only one of relationships between the factors was statistically significant, and, because our aim was to reveal latent classes relating to our research model, we continued with FMSEM even though our model was also found to be acceptable to some extent with the assumption of homogeneous data.
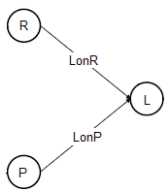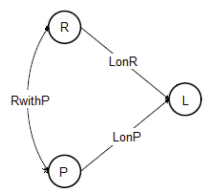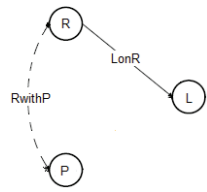
Mixture modeling refers to modeling with categorical latent variables that represent subpopulations where the population membership is not known but is inferred from the data (McLachlan and Peel 2000; Muthen and Muthen 1998–2007). This approach extends the classic multi-group SEM to a situation in which group membership is unfamiliar and cannot be determined a priori (Bart et al. 2005). In practice, the model was first estimated using one latent class, then two latent classes, and so on, until the model-fit information indicated that the previous model was better than the current model (See Table 3).

Table 3. Evaluation of latent classes

Classes	n	Entropy	LogLH	AIC	BIC	ABIC	VLMRLRT	LMRALRT	PBLR
1	173	n/a	2526	5112	5206	5111	n/a	n/a	n/a
2	10/163	0.973	2501	5064	5161	5063	0.043	0.047	0.105
3	110/40/23	0.735	2478	5033	5153	5032	0.356	0.366	0.474
4	13/39/8/113	0.831	2460	5010	5152	5009	0.316	0.322	0.059
5	15/19/21/14/104	0.804	2459	5021	5185	5021	0.848	0.847	1.000

MPlus software offers multiple fit indices to compare different outcomes. When comparing results as a whole, and because with a small sample size (less than 500) the most reliable fit indices are Bayesian information criteria (BIC) and parametric bootstrapped likelihood ratio (PBLR) (Tolvanen, 2007), we arrived at a solution of four latent classes.

Table 4. Description of the found latent classes.

Latent class model				
N	**13**	**39**	**8**	**113**
RwithP	0.953	N/A	1.237	-0.302
(p-value, 2-t)	(0.004)	(0.348)	(0.000)	(0.085)
(p-value, 1-t)	(0.002)	(0.174)	(0.000)	(0.043)
LonR	N/A	1.010	0.175	1.683
(p-value, 2-t)	(0.767)	(0.000)	(0.032)	(0.002)
(p-value, 1-t)	(0.384)	(0.000)	(0.016)	(0.001)
LonP	N/A	0.728	0.818	N/A
(p-value, 2-t)	(0.765)	(0.003)	(0.000)	(0.445)
(p-value, 1-t)	(0.383)	(0.002)	(0.000)	(0.223)

The descriptions of the latent classes can be found from table 4 and descriptions of the average values of the variables of the latent classes are presented in the figure 3.
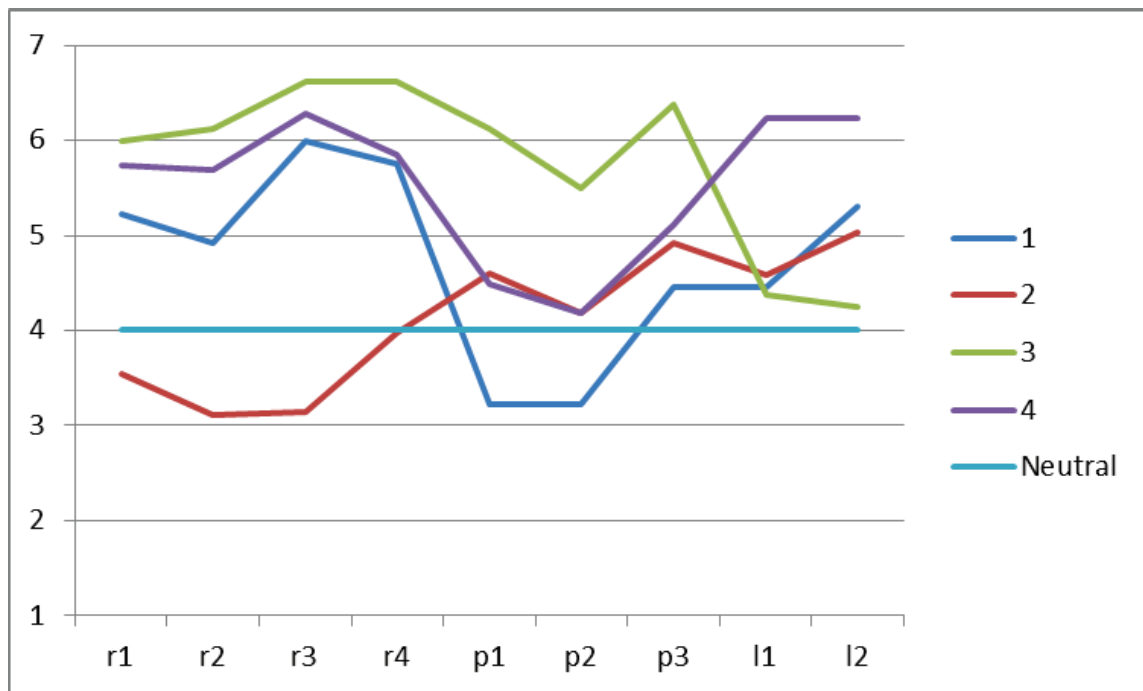
Figure 3. Averages in classes

DISCUSSION

Reviewing our data as a whole suggests that only the quality of the relationships positively influences customer loyalty intentions, and that there is no statistical relationship between negotiating power and the quality of the relationships. However, SEM includes statistically insignificant relationships and hence cannot be used as the basis for final judgements. Thus we choose to place more emphasis on the results from the FMSEM.

In the first latent class (7.5 % of the whole population), we found a strong association between negotiating power and the quality of relationships. Interestingly, this group of respondents offered the lowest evaluation of breweries' negotiating power. Furthermore, neither the quality of the relationships nor the negotiating power influenced loyalty intentions. Hence, we interpret this small group of respondents as comprising customers who are not strongly independent from breweries, but are able to choose their business partners relatively freely. However, their loyalty intention is at a quite high level and thus we named the group *strong customers*. Our assumption is that this group consists of buyers who represent, for example, large restaurant or hotel chains buying high volumes, which explains their strength as a buyer.

In the second latent class (22.5 % of the whole population), the association between negotiating power and the quality of the relationship was statistically insignificant. However, both independent factors strongly influenced customer loyalty intentions. The quality of the

relationship was low, and the association of the brewery's negotiating power with customers' loyalty intentions was close to a moderate level. The empirical results in this second latent class prompted us to name the group *distant customers.*

In the third latent class (4.6 % of whole population), the associations between all factors were statistically significant. In this group, however, the influence of the quality of the relationships on loyalty intentions was quite weak, but the influence of the brewery's negotiating power on customer loyalty intentions was strong. The quality of the relationship was at a high level along with breweries' negotiating power, but customer loyalty intentions were at the lowest level compared to other latent classes. Our interpretation is thus that customers are not loyal because they want to be, but rather because they are so dependent on the brewery that they have no other choice. Hence, we named this group as *dependent customers*.

The fourth, and the largest, latent class (65.3 % of the whole population) offers interesting results. Only the quality of the relationship influenced customer loyalty intentions. In addition, the quality of the relationships is at a high level along with customer loyalty intentions, while the brewery's negation power is at close to a moderate level. We applied a one-tailed probability test to explore if there was a trade-off between negotiating power and the quality of the relationships. We found a negative association between negotiating power and the quality of the relationship, which indicates that the trade-off in question does indeed exist. To summarize the findings on this latent class, changes to negotiating power negatively influence the quality of the relationships and the good quality of the relationships explains high customer loyalty intentions. Consequently, we named this group "business partners". Our assumption concerning this group is that it encompasses all individual operators, known in the business as "man and a tap" customers.

From a theoretical perspective our findings suggest that searching for a universal model was unproductive, but we needed to accept that there are latent classes that behave differently and which must be revealed if we were to understand this phenomenon comprehensively. From managerial perspectives it thus would benefit from identifying power-relationship-loyalty customer segments that are behaving differently comparing to other segments and managing the various customer segments in different ways. Supplied with that understanding and an ability to position the several latent actual classes based on behaviour against the correct customer segments, the seller of business to business products or services could potentially considerably increase its profitability. Hence, a deeper examination of costs and prices with power coalitions would probably offer interesting knowledge gains from the both theoretical and managerial perspectives.

CONCLUSIONS

The purpose of this research was to study how the quality of certain relationships associates with negotiating power and in addition how the quality of those relationships and negotiating power influence loyalty intentions. From a theoretical perspective, we found that searching for a universal model was unproductive, but we needed to accept that there are latent classes that behave differently and which must be revealed if we were to understand this phenomenon comprehensively. The data exposed four latent classes, customer segments that may well not have been revealed by a classic segmentation approach based on demographics features of the customer, however, the mixture analysis did effectively expose them.

The implications of the study for management are very interesting. We suggest that a seller of a business to business service, at least in the brewing industry, would benefit from identifying power-relationship-loyalty customer segments that are behaving differently comparing to other segments and managing the various customer segments in different ways. There are some strong customers who are probably primarily interested in the prices of the products; distant customers who need to be treated as traditional business to business customers; small groups of dependent customers that perhaps demand less attention from the brewery; and finally a large group of business partners who are primarily interested in the transactional value of the relationship. Armed with that understanding and an ability to position the various latent actual classes based on behaviour against the correct customer segments, the seller of business to business products or services could potentially considerably increase its profitability.

In addition, from a methodological perspective we found that mixture analysis, and FMSEM specifically, is a very powerful tool to reveal real behaviour-based latent classes. Hence we suggest that researchers should accept that their data is probably not homogeneous as is usually assumed, but should accept the possibility that their data is heterogeneous and adopt mixture analysis in those situations where testing an empirical model provides an inadequate statistical fit.

The limitations of this research mainly derive from the fact that our data consist of only one company's customers, and furthermore, those customers come from one country. In addition, we limited our study to three factors, and acknowledge that adding factors, such as image and market situation, would offer many new and interesting avenues of research. Another interesting future research topic would be that how have well demographic features of the customer in reality explains existence and actual behaviour of latent classes. Moreover, a deeper examination of costs and prices with power coalitions would probably offer interesting knowledge gains. We very much hope that our research spawns further research on the concepts explored here and encourages researchers to adopt mixture analysis methods.

REFERENCES

1. Browne and Cudeck (1993) *Alternative ways of assessing model fit.* In: Bollen, K. and Long, J.S. Eds. (1993) Testing Structural Equation Models. Sage Publications Inc. Palm Springs.

2. Cox, A. (2004), The art of the possible: relationship management in power regimes and supply chains. *Supply Chain Management: An International Journal*, Vol. 9 No.5, pp. 346-56.

3. Cox, A. (1999), power, value and supply chain management. Supply Chain Management: An International Journal, Vol. 4 No.4, pp. 167-175.

4. Jaccard, J. and Wan, C.K. (1996) *Lisrel approaches to interaction effect in multiple regression,* Sage Publications Inc. California.

5. Jarillo, C. J. (1988) On strategic networks. *Strategic Management Journal,* Vol. 9, pp.31-41.

6. Juntunen, J. (2010) Functional spin-offs in logistics service markets. *International Journal of Logistics: Research and Applications,* Vol. 13, No. 2, pp. 121–132.

7. Larson, P. D. (2005) A Note on mail surveys and response rates in logistics research. *Journal of Business Logistics,* Vol. 26, No. 2, pp. 211-222.

8. McLachlan, G. and Peel, D. 2000. Finite mixture models. New York: John Wiley and Sons.

9. Muthen, L.K. and Muthen, B.O. 1998-2007. Mplus user's guide. Fifth edition. Los Angeles: Muthen and Muthen.

10. Bart, Y., Venkatesh, S., Sultan, F. and Urban, G.L. 2005. Are the Drivers and Role of Online Trust the Same for All Web Sites and Consumers? A Large-Scale Exploratory Empirical Study. Journal of Marketing 69 (4): 133–152.

11. Tolvanen, A. 2007. Latent growth mixture modeling: a simulation study. Jyväskylä: Jyväskylä University Press.

12. Stock, R.M. (2005), Can customer satisfaction decrease price sensitivity in business-to-business markets? Journal of Business-to-Business Marketing, Vol. 12 No. 3, pp. 59-87.

E-SUPPLY CHAIN INTEGRATION ADOPTION: EXAMINATION OF BUYER-SUPPLIER RELATIONSHIPS

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ABSTRACT

The purpose of this study is to empirically examine the adoption of e-supply chain integration by electrical and electronic companies. The study aims to understand the adoption decisions by suppliers based on the buyer-supplier relationships. Research model for this study derived from the transaction cost and resource dependence theories. Data were collected from 122 electrical and electronic suppliers. The data was examined using Partial Least Squares (PLS). The results showed that Asset Specificity, Product Technological Uncertainty, Transaction frequency, Proportion of sales to e-supply chain integration promoter, and number of customers are able to explain suppliers' decisions to adopt e-supply chain integrations with their buyers. Buyers that would like to improve the adoptions of e-supply chain integration will be able to formulate and plan strategies from the buyer-seller relationships perspectives. This study has integrated both the transaction cost and resource dependence models in understanding the influence of buyer-seller relationships on e-supply chain integration. Past studies have focused on Electronic Data Interchange (EDI) which has limitations such as costs, compatibility, and lack of standard issues. As web technologies have overcome these limitations, we are able to purely focus on the roles of buyer-seller relationships.

Keywords: E-supply chain integration, transaction cost theory, resource dependence theory, buyer-supplier relationships, electrical and electronics industry, multiple regression analysis

CUSTOMERS CHOOSE WHERE TO SIT BY WHAT TO DO-THE RELATIONSHIP OF TABLE SELECTION AND CUSTOMER BEHAVIOR IN COFFEE SHOPS

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ABSTRACT

Purpose: The purpose of this study is to explore the relationships among where (which table) customers choose to sit, what they are doing and how long they will stay when consuming in a coffee shop.

Methodology and Design: The present study was conducted by naturalistic observation and recorded duration, party size, consumer's behavior, expense and the table being selected to seat in three types of coffee shops, including chain stores, combinational stores and specialty stores. For the purpose, the types of tables were classified according to number of anchors.

Findings: A total of 344 observations (a table as a unit) were observed in coffee shops, and the sample contained 144 lone individuals and 200 group members. Our results show that the behavior of reading or surfing will result in longer duration in a coffee shop. Further, people who read or surf prefer to choose anchored tables.

Managerial implications: According the results, we suggest that if managers want to create a coffee shop to suit for reading could build more seats with one anchor beside wall or window, and the best percentage of anchored tables is middle level (71% to 90%) which has the lowest duration and the highest average check. We also suggest that combinational store is better earning model because of having highest average check by providing meal and lower duration.

Keywords: Coffee shop; Table selection; Anchored table; Consumer behavior; Reading; Duration

INTRODUCTION

When people visit a coffee shop, do they choose where to sit according to what they want to do? And how does this behavior affect the revenue of a shop? In Thompson (2010), it addressed 38 decision issues of *restaurant profitability management* (RPM). Among them, *layout design* is one of these means that are very important to RPM. But previous literatures

of layout design only focused on discussions about preferences of consumers, privacy level, duration and expense, which haven't discussed the relationship between table selection and consumer behavior yet.

On the other hand, the past restaurant management studies used to focus on the relationships among many variables, for example: meal duration, group size, amount eaten, expense, social facilitation and so on. Until Sommer and Steele (1997)found that consumer with reading stayed longer than no-readings, reading behavior started to get a little attention. Reading is a common activity in coffee shops (Sommer & Steele, 1997), but there is a gap between reading and table selection which has not discussed yet. The purpose of this study is to explore the relationship between where to sit and what to do in order to provide coffee shop managers some rules to allocate their table locations that suit their store styles.

LITERATUREREVIEW

Kimes, Barrash, and Alexander (1999) proposed the definition of *restaurant revenue management*(RRM) as selling the right seat to the right customer at the right price and for the right duration. From the definition, we can realize the importance of duration and table selection and that both of these variables will affect revenue.

Duration can be defined as the time from arrival at the table to departure (Kimes et al., 1999). Many research found that reading behavior will increase duration (Brindal, Wilson, Mohr, & Wittert, 2011; Sommer & Steele, 1997), and the longer druation takes the greater intake of food (Bell & Pliner, 2003), even better privacy level of seat will generate longer duration and higher average check (Kimes & Robson, 2004). Thus, this gives the following hypothesis:

H1a: There is a positive relationship between reading behavior, table selection, duration, and expense.

Reading is asocial activity (Sommer & Steele, 1997), so there must be a relationship between reading behavior and anchored table which can keep personal privacy and space (Robson, 2002). Thus, this gives the following hypothesis:

H1b: There is a positive relationship between reading behavior and table selection (anchored tables).

Reading behavior includes using technical products (Brindal et al., 2011), and any products being used for digital reading bring into consideration, for example: notebook, tablet PC, smart phone (Hsiah, 2010). Moreover, in the case of technology products being popular, restaurants providing WIFI can increase customer's intention to return to restaurants (Cobanoglu, Bilgihan, Nusair, & Berezina, 2012). Thus, this gives the following hypothesis:

*H2:*There is a positive relationship between free WIFI and reading behavior.

Robson (2002, 2008) defined anchored table as seats positioned next to some form of permanent or semi-permanent design feature, like exterior walls, pillars, interior partitions and so on. Moreover, more anchors will keep better privacy level, and generate satisfaction. Kimes and Robson (2004) divided tables into the following six types: anchored tables – Booth, Banquette, Exterior Window, Interior Window, Hall Wall, and unanchored tables. This study classifies tables according to number of anchors, for examples: a table with wall or window is one-anchor table; a corner table is two-anchor table, and considered the higher percentage of anchored tables of total tables will increase duration and reading behavior. Thus, this gives the following hypothesis:

*H3:*The percentage of anchored tables has a positive effect on duration and reading behavior.

METHOD

Design

The present study was conducted by naturalistic observation (Brindal et al., 2011; Sommer & Sommer, 1989; Sommer & Steele, 1997). A researcher entered an object coffee shop as a customer (order and consume) and recorded other customers' behavior under unobtrusive way. Due to varied styles of coffee shops with different characteristics may affect duration and average check, so this study classifies coffee shops into three types: chain stores, combinational stores and specialty stores based on Lin and Yang (2003) and Chen, Zhang, and Yang (2006) classifications. This study respectively chose three shops for each type as our observation objects.

Sample and Data Collection

The investigation period was from mid-September to the end of October in 2013 and the observation duration was from 11:30 a.m. to 5:30 p.m.. Totally nine coffee shops were observed, three shops in each coffee shop style (chain stores, combinational stores and specialty stores). A total of 344 observations (a table as a unit) were observed in coffee shops, and the sample contained 144 lone individuals and 200 group members.

Procedure

After entering coffee shop to order the food and have a seat, the investigator started to observe customers who entered behind him or her. The investigator recorded the time when customers arrived and departed in order to count the duration, their genders, the size of their group, the relationship of the group (friends/ colleagues/ family/ individual), their behaviors, their expenses and their table selection (one anchor/ two anchors/ three anchors/ no anchor). The behaviors being recorded focused on reading (includes using technical products, like notebook, tablet PC, smart phone), and other behaviors, for example: chatting, daydreaming and so on.

Analysis

Descriptive statistics, multivariate analysis of variance (MANOVA), analysis of variance (ANOVA) and Chi-square Test were conducted to analyze the observed data.

RESULTS

The followings were the results of descriptive statistics: data were recorded for 344 observations (a table as a unit) and 270 of these were reading newspaper, books, magazines, and using technical products (78.5 %). Duration ranged from 11 minutes to 325 minutes with an average of 90.85 minutes (SD= 55.43), and average check ranged from \$1.15 to \$12.14 with an average of \$5.02.

After determining that there was homogeneity of variance between reading behaviors and table selection, a multivariate analysis of variance (MANOVA) was conducted using reading behaviors and table selection as independent variables, with duration and expense as dependent variables. Table 1 shows that only the effect between reading behaviors and duration is statistically significant (F= 9.391, p = .002) while the interaction is not. Consumers with reading stayed longer than those not reading. Therefore, Hypothesis 1a is supported partly.

TABLE 1 Results of Multivariate Analysis of Variance (MANOVA) of Reading Behaviors, Table Selection as independent variables and Duration, Expense as dependent variables

Source	Dependent Variable	SS	df	MS	F	ρ
Reading Behaviors	Duration	29096.55	1	29096.55	9.39**	.002
	Expense	181.38	1	181.38	.08	.774
Table Selection	Duration	10469.12	3	3489.71	1.13	.339
	Expense	11452.13	3	3817.38	1.74	.160
Reading * Table Selection	Duration	15085.15	2	7529.07	2.43	.090
	Expense	6207.69	2	3103.85	1.41	.245
Error	Duration	938841.31	303	3098.49		
	Expense	666241.58	303	2198.82		
Total	Duration	3581733.00	310			
	Expense	7863847.00	310			

Note. Adapted from the present study.
** $\rho < .01$.

Proceedings of 2014 International Conference on
Technology Innovation and Industrial Management
28th-30th **May 2014, Seoul, South Korea**

Further, a Chi-square Test was conducted to investigate the relationship with reading behaviors and table selection. The result was statistically significant: $\chi2(3, N= 310) = 11.276$, $\rho < .05$. The result of analysis is presented in Table 2, which indicates that consumers with reading behaviors apparently prefer selecting the table with anchor(s) (one or more than one anchor), and specially prefer the table with one anchor. Therefore, Hypothesis 1b is supported.

TABLE 2 Results of Chi-square Test of Reading Behaviors and Table Selection

	No anchor		One anchor		Two anchors		Three anchors		χ^2	ρ
	Frequency	%	Frequency	%	Frequency	%	Frequency	%		
No read	13	38.2%	27	15.6%	25	25.3%	0	0.0 %	11.276	$\rho < .05$
Read	21	61.8%	146	84.4%	74	74.4%	4	100.0%		

Note. Adapted from the present study.

Also a Chi-square Test was conducted to investigate the relationship with WIFI (free of charge / charge) and reading behaviors. (Originally, we want to investigate that whether WIFI being provided will affect reading behaviors, but there are no coffee shops without WIFI in this age. Accordingly, we investigate WIFI whether being charged.) The result was not statistically significant: χ^2 (1, N= 344) = .769，$\rho> .05$. Therefore, Hypothesis 2 is not supported.

To calculate the percentage of anchored tables, the researcher drew out the layout of coffee shops. The percentage of anchored tables was the number of anchored tables which be divided by total number of tables. After getting the percentage of anchored table of the coffee shops respectively, the study graded the several percentages into three level based on values: low level (from 51 % to 70 %), middle level (from 71 % to 90 %) and high level (from 91 % to 100 %).

After determining that there was homogeneity of variance, two one-way analysis of variances (ANOVA) were conducted using the percentage of anchored tables as independent variable, with reading behaviors and duration as the dependent variables separately. Table 3 shows the effect on reading behaviors which is statistically significant (F= 5.884, p = .003) and the effect on duration which is also statistically significant (F = 5.318, p = .005), too.

The results of analysis are presented in Table 4, which indicates that there were more consumers with reading in low and high level of coffee shops than middle level, and duration was shortest in middle level of coffee shops. Therefore, Hypothesis 3 is supported partly.

Additionally, the present study found that there is statistically significant (F= 18.696, p= .000) on average check as dependent variable by conducting a one-way analysis of variance (ANOVA) presenting in Table 3. The result showing in Table 4 indicates the average check in middle level of coffee shops was higher than low and high level.

In brief, middle level of coffee shops has more consumers with reading, shortest duration and higher average check, and oppositely low and high level of coffee shops have less consumers with reading, longer duration and lower average check.

TABLE 3 The Results of One-Way Analysis of Variances (ANOVA) of the Percentage of Anchored Tables as independent variable with Reading Behaviors, Duration, and Average Check as dependent variable

	Source	SS	df	MS	F	ρ
Reading Behaviors	Between Groups	1.897	2	.948	5.884**	.003
	Within Groups	49.474	307	.161		
	Total	51.371	309			
Duration	Between Groups	32932.055	2	16466.028	5.318**	.005
	Within Groups	950474.619	307	3096.009		
	Total	983406.674	309			
Average Check	Between Groups	75259.689	2	37629.844	18.969***	.000
	Within Groups	609008.831	307	1983.742		
	Total	684268.519	309			

Note. Adapted from the present study.
*** $\rho < .001$ ** $\rho < .01$

TABLE 4 The Results of Descriptive Statistics of three level of the Percentage of Anchored Tables with Reading Behaviors, Duration, and Average Check

Variables	Low Level ($n = 49$)				Middle Level ($n = 129$)				High Level ($n = 132$)			
			95% Confidence				95% Confidence				95% Confidence	
	M	*SD*	Lower Bound	Upper Bound	*M*	*SD*	Lower Bound	Upper Bound	*M*	*SD*	Lower Bound	Upper Bound
Reading	.86	.354	.76	.96	.70	.461	.62	.78	.86	.352	.80	.92
Duration	112.55	62.33	94.65	130.45	82.27	46.27	74.21	90.33	92.83	61.16	82.30	103.36
Average Check	143.92	33.09	136.25	151.59	188.91	50.62	173.88	203.94	146.51	46.91	139.80	153.22

Note. Adapted from the present study.

Moreover, after determining that there was homogeneity of variance among three types of coffee shops (chain stores, combinational stores and specialty stores), two one-way analysis of variances (ANOVA) were conducted using three types of coffee shops as independent variable, with duration and average check as the dependent variables separately. Table 5 shows that the effect on duration which is statistically significant ($F= 7.582, p = .001$) and the effect on average check which is also statistically significant ($F = 16.977$, $p = .000$), too.

It means that there are relationships between types of coffee shops and duration, average check. The results of analysis are presented in Table6, which indicates that there was the longest duration in specialty stores ($M= 104.79$) than combinational stores ($M= 87.44$) and chain stores ($M= 78.43$); and there was the highest average check in combinational stores ($M= 168.47$) than specialty stores ($M= 157.62$) and chain stores ($M= 133.67$).

In brief, we can differentiate these three types of coffee shop as following: chain stores have the shortest duration and lowest average check; combinational stores have shorter duration and the highest average check; and specialty stores have the longest duration and lower average check.

TABLE 5 The Results of One-Way Analysis of Variances (ANOVA) of Three Types of Coffee Shops as independent variable with Duration, and Average Check as dependent variable

	Source	*SS*	*df*	*MS*	*F*	*ρ*
Duration	Between Groups	44866.757	2	22433.378	7.582**	.001
	Within Groups	1008895.976	341	2985.639		
	Total	1053762.733	343			
Average Check	Between Groups	69907.47	2	34953.737	16.977***	.000
	Within Groups	702060.84	341	2058.829		
	Total	771968.31	343			

Note. Adapted from the present study.

*** ρ < .001

TABLE 6 The Results of Descriptive Statistics of Three Types of Coffee Shops with Duration, and Average Check

Variables	Chain stores (*n* = 120)				Combinational stores (*n* = 94)				Specialty stores (*n* = 130)			
	M	*SD*	95% Confidence Lower Bound	Upper Bound	*M*	*SD*	95% Confidence Lower Bound	Upper Bound	*M*	*SD*	95% Confidence Lower Bound	Upper Bound
Duration	78.43	51.11	69.20	87.67	87.44	47.71	77.67	97.21	104.79	61.41	94.14	115.45
Average Check	133.67	35.05	127.33	140.00	168.47	49.28	158.38	178.56	157.62	50.58	148.84	166.39

Note. Adapted from the present study.

CONCLUSION

The present study investigated at nine coffee shops and proposed four hypothesizes to be confirmed. Three of the four hypothesizes are supported or partly supported, only Hypothesis 2 is not supported. We consider the reason is that due to the popularity of mobile Internet device. Consumers do not depend on WIFI to begin digital reading, instead, they can use their own mobile Internet device. In order to verify the findings proposed by Sommer and Steele (1997) and Brindal et al. (2011) that reading behaviors increased longer duration, the study also combined the growing trend of the availability of digital reading to provide managerial implications about coffee shops.

According to the results, we suggest that if managers of coffee shops want to set up a coffee shop that suit for reading, they could arrange more seats with one anchor beside wall or window, and the best percentage of anchored tables is the middle level (71% to 90%), which indicates managers still have to keep some unanchored tables, because the middle level generates the lowest duration and the highest average check.

Regarding to the selection of type of coffee shop, we suggest that combinational store is a better profitable model because of having the highest average check by providing a lower average meal duration. Although the chain store type makes the lowest average check, it still could use the lowest duration to increase turnover rate to raise overall revenue for a coffee shop. And specialty store has the longest duration, but it still could provide leisurely coffee time to increase consumers' loyalty and intention to come to coffee shop to make up a deficit of low average check.

REFERENCES

1. Bell, Rick, & Pliner, Patricia L. (2003). Time to eat: the relationship between the number of people eating and meal duration in three lunch settings. *Appetite, 41*(2), 215-218.
2. Brindal, Emily, Wilson, Carlene, Mohr, Philip, & Wittert, Gary. (2011). Does meal duration predict amount consumed in lone diners? An evaluation of the time-extension hypothesis. *Appetite, 57*(1), 77-79.
3. Chen, Hong-Jun, Zhang, Guang-Tong, & Yang, Wen-Can. (2006). *The Awareness of Coffee Consumption of Consumers*. Paper presented at the Health and Leisure.
4. Cobanoglu, Cihan, Bilgihan, Anil, Nusair, Khaldoon, & Berezina, Katerina. (2012). The Impact of Wi-Fi Service in Restaurants on Customers' Likelihood of Return to a Restaurant. *Journal of Foodservice Business Research, 15*(3), 285-299.
5. Hsiah, Rung. (2010). *Experience of Digital Reading Service-A Study on User's Intention and Preference in Smartphone, e-Reader, and tablet PC.*(Master), National Taiwan Univerity, Tapei, Taiwan.
6. Kimes, Sheryl E, Barrash, Deborah I, & Alexander, John E. (1999). Developing a restaurant revenue-management strategy. *Cornell Hotel and Restaurant Administration Quarterly, 40*(5), 18-29.
7. Kimes, Sheryl E, & Robson, Stephani K. A. (2004). The Impact of Restaurant Table Characteristics on Meal Duration and Spending. *Cornell Hotel and Restaurant Administration Quarterly, 45*(4), 333-346.
8. Lin, Yu-Zheng, & Yang, Hai-Quan. (2003). *Open a Successful Coffee Shop*. Taipei, Taiwan: United Culture.
9. Robson, Stephani K. A. (2002). A review of psychological and cultural effects on seating behavior and their application to foodservice settings. *Journal of Foodservice Business Research, 5*(2), 89-107.
10. Robson, Stephani K. A. (2008). Scenes from a restaurant: Privacy regulation in stressful situations. *Journal of Environmental Psychology, 28*(4), 373-378.

11. Sommer, Robert, & Sommer, Barbara A. (1989). Social facilitation effects in coffeehouses. *Environment and Behavior, 21*(6), 651-666.
12. Sommer, Robert, & Steele, Jodie. (1997). Social Effects on Duration in Restaurants. *Appetite, 29*(1), 25-30.
13. Thompson, Gary M. (2010). Restaurant Profitability Management: The Evolution of Restaurant Revenue Management. *Cornell Hospitality Quarterly, 51*(3), 308-322.

MANAGING THE CUSTOMER WAITING PROBLEM IN FAST FOOD RESTAURANTS IN TAIWAN THROUGH REENGINEERING OF THE APP ORDERING PROCESS

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Purpose: *The aim of this research is to manage the customer-waiting problem in Taiwanese fast food restaurants through reengineering of the APP ordering process.*

Design/methodology/approach: *This research uses a literature review to identify different approaches of reengineering and use them to improve the APP ordering process used in Taiwanese fast food restaurants.*

Findings: *This research has identified six approaches of reengineering, which can be applied to improve the APP ordering process in fast food restaurants. The application of the reengineering approaches, in the APP ordering process in Taiwanese fast food restaurants, generated four suggestions of how to improve the original APP ordering process.*

Research limitations/implications: *The subsequent research can apply other research methods to improve the reliability and validity.*

Practical implications: *The application of reengineering approaches to improve the APP ordering process in fast food restaurants can be used in other country's food industry and be adapted to other industries as well. The research could also provide a basis for companies that want to implement the APP ordering system.*

Originality/value: *This research clarifies the customer-waiting problem in the APP ordering process in Taiwanese fast food restaurants and applies reengineering approaches to improve the original APP ordering process.*

Keyword: Customer waiting time, Reengineering, APP, fast food.

Paper type: Research paper

INTRODUCTION

When customers like the product or service provided by a fast food restaurant, the problem of customer waiting time occur. This is a critical issue that most fast food restaurant managers need to focus on. This is the reason why this paper addresses the topic of improving waiting time in Taiwanese fast food restaurants. The first issues to consider in the design of a fast food service organization are what to offer and how to satisfy the customers (Parasuraman, et al., 1991). In the present, fast tempo life-style environment, the use of time has become more and more important to customers (Lai and Lee, 2013). Depending on the diversification of service quality, customers have started to pay attention to, the problem of waiting time. Now, long waiting times usually is a reason why customers feel dissatisfied and complain (Chang et al., 2003). Therefore, improvement of waiting times in fast food restaurants is an important research topic in today's intense and competitive environment in order to enhance the service quality and to satisfy the customers.

The approaches companies use to communicate with their customers have changed radically since the arrival of the APP. Companies can use APPs to realize the demand from customers and they can allow customers to use APPs to buy online. In addition, companies can use APPs to share marketing information and for other branding purposes. In order to tackle the problem with long customer waiting times in individual restaurant sites, many restaurant chains have launched own APP ordering services to allow the customers to order directly online. The advantage of using the APP ordering system is that the meal can be ordered anytime, no matter where the customer is located. In addition, the customer does not need to worry about the clerk forgetting the order by phone or misunderstanding the order. For the restaurants managers, the APP ordering system can scatter crowds effectively, prepare for food material more accurate, and expand the customer base.

McDonald's, the largest fast food restaurant chain in America, begun to test the APP ordering system in 2011, due to the customers decreased tendency to dine out, and launched it in 2013 (Lutz, 2013). KFC in Britain begun to test the APP ordering system, in the 10 restaurant sites located in London, during 2013 (Kana, 2013). The APP ordering system allows the customers to order before they come to the restaurant site to decrease the waiting time (Williams, 2013). In addition, the fast food restaurant chains Domino's Pizza Hut and Grill Chipotle Mexican have launched APP ordering systems. This shows that different fast food restaurant chains across the world have begun to develop and launch their own APP ordering systems. However, the APP ordering process in one country is not necessarily suitable for another one. For example, the culture, languages, and consumption patterns differ. In addition, Taiwan is a tiny country with short distances between home and work. Therefore, the APP ordering processes used in Taiwan probably are different.

Although customers currently enjoy the convenience of shorter waiting times by using the existing APP ordering systems, the available systems are not completely developed and many of them are still just tests. Most of the available APP ordering systems on the Taiwanese food market, have been developed by the large fast food restaurant chains. If the outcome of using APP ordering system is good for both the customers and the restaurant chains, and when the APP ordering system has become more developed, many small and medium-sized restaurants will follow. Hence, in addition to large fast food restaurant chains, small and medium-sized restaurant owners in the future probably can enhance their competiveness by developing own APP ordering systems. They can use the APP ordering systems available on the market as reference to reduce the cost of development and testing.

The aim of this research is to manage the customer-waiting problem in Taiwanese fast food restaurants through reengineering of the APP ordering process. This issue has been examined in three subsequent steps. Firstly, a literature review has been conducted to identify various reengineering approaches that can be used to improve the APP ordering process in fast food restaurants. Secondly, the existing APP ordering systems provided by fast food restaurant chains in Taiwan (such as KFC and MOS) have been tested in order to develop a general APP ordering process. Finally, the identified reengineering approaches have been applied on the developed APP ordering process to propose improvements of the process.

LITERATURE REVIEW

This section describes a background of APPs and the usage of them. In addition, different reengineering approaches, relevant for this study, are described. The two issues are described in turn below.

APP

The way companies communicate with its customers has changed drastically since the APP technology was introduced. The huge increase in APP usage has resulted in that companies have stated to use APPs to provide marketing services and for other branding purposes. For example, the Italian fashion company, Gucci, has their own APP in the iPhone APP store to get customers to look (browse) at the latest news and products. In addition, people use APPs to interact and connect with each other. This implies that many companies are interested in entering the APP market (Cortimiglia et al., 2011).

In the beginning, only one platform existed where APPs could be downloaded and used. This platform was provided by Apple and allowed people to download APPs from Apple's APP store to their iPhones and iPods. Today, several other platforms also exist where APPs can be downloaded. For example, Google's Android market, Blackberry's APP world, Nokia's Ovi store, Microsoft's Windows market (Ayalew, 2011).

There is currently no standard for the classification of APPs in the different downloading platforms. The classification of the APPs is instead different in each downloading platform. Some common classifications of the APPs include transaction, communication, information tool, entertainment, and learning (Hsu, 2013).

The APP usage has increased a lot in the recent years. The total number of downloads from 2008 to 2011 is ten billion (Yang, 2009; Chen, 2012). The large amount of downloads signifies that the APP has been accepted and is used by many people (Yang, 2009). In fact, most of the time people spend on their smart phones involves the use of APPs, very little time is spent on Internet or other phone related things. This phenomenon shows that people can get information and service without using a browser, but with an APP. It also shows the people Internet habits have been affected by the APP and the importance of the APP has also gradually increased.

Reengineering approaches

Hammer & Champy (2006) argues that Business Process Reengineering (BPR) is a customer demand-oriented method to transform an organization in order to maintain flexibility and to gain competiveness. The objective is to improve the cost of quality, service and operating speed by updating the entire working process and using approaches such as brainstorming to think and change continuously (Hammer & Champy, 2006). According to King & Teo (1996), organizational resources and IT technical support are needed to transform business processes.

Table 1: Reengineering approaches

Approach	Explanation from food ordering perspective	Source
Combine	Merge different works into one and deal with it simultaneously	Cheng et al. (2000)
Isolate	Isolate the work, which has a specific working process in order to deal with it more quickly	Cheng et al. (2000)
Strengthen connections	Strengthen the connection between customers and restaurant managers	Cheng et al. (2000)
Integrated activities	Share and combine each database to provide customers with information in a short time	Geng et al. (2009)
Benchmark targeting method	Learn from the best companies in the industry and use this knowledge to improve the own ordering process	Cheng et al. (2009); Klein (1993)
Rearrange	Rearrange the activities in original ordering process to develop a new and more efficient ordering process	Gao et al. (2007)

Several reengineering approaches (or methods) have been proposed in the literature. Cheng et al. (2000) describe a Japanese accounting firm that used three methods ("combine", "isolate", and "strengthen connections") to transform the traditional business processes. Geng et al. (2009) describe seven methods for improving the process of public service organizations. One of the seven methods, relevant in this study, is "integrated activities". The method "integrated activities" is a platform based on information sharing. Information sharing represents a revolutionary change for traditional business processes and concerns customers and suppliers as well as the internal business processes. The method implies that data is collected and stored in a database to allow continues information to be shared with key customers and suppliers and between business processes. Klein (1993) describes the so-called benchmark targeting method. This method implies that the company compares itself with the best companies engaged in the same activities and tries to find solutions on how to improve the weak point of the process. Cheng et al. (2009) applied business process reengineering to develop a new method of transforming the management in a company. This new method is called the benchmark targeting method. For example, one of the involved companies chose the best company in its industry, which had implemented the same activities, compared and learned the better parts of their process and used this knowledge to improve their own process. Furthermore, Gao et al. (2007) show that if we take the parts of the original process in an organization and rearrange them, we can enhance efficiency. Table 1 provides a summary of the six reengineering approaches discussed above. It is also explained in what way they are relevant in the current study.

THE APP ORDERING PROCESS

This section describes a general APP ordering process used in Taiwanese fast food restaurant chains. The process has been formed, by using the APP ordering systems provided by various fast food restaurant chains in Taiwan (such as KFC and MOS). The investigation showed that the APP ordering system in these fast food restaurant chains usually included four functions: Order, Information, Record, and Other sites information. The customer accesses the four functions on the APP ordering system's front page. To make an order, the customer selects the order function, and enters information about what dishes to have, where to have the meal, how to have the meal, when to have the meal, as well as name and phone number. After that, the customer can come to the selected restaurant site at the specified time to have the meal. In general, the APP ordering process can be divided into four steps, which are described in more detail below.

Step 1: Enter the APP front page, member register, and login.
When the customer enters the APP ordering system's front page, the available core functions (usually order, information, record, and other sites information) can be accessed. Some APP ordering systems will request the customer to register and login, in order to be able to make an order. The order function provides the customer with the ordering service and information about the menu (dishes with picture and price), locations to have the meal, and ways to have

the meal (pick up at drive-thru window or dine at the restaurant). The information function provides the customer with the latest news about the fast food restaurant chain, for example, news about product listing, promotion, and advertisements. The record function shows all the meal orders, which the customer has made in the past, and all the meal orders with processing status. The other sites information function provides the customer with a map to show the location of other restaurant sites in the chain.

Step 2: Make an order

After the customer has studied the menu and decided what dishes to order, the customer continues by pushing on the order button. The system will request the customer to choose what dishes to have and quantity, where to have the meal (restaurant site), how to have the meal (pick up at drive-thru window or dine at the restaurant), when to have the meal (time), and how to pay for the meal (e.g., gift, cash, or points).

Step 3: Confirm the order and submit

After the customer has entered all the order information, the next step is to confirm the order. The customer can see pictures and explanation of all selected dishes and control the order visually. In addition, the customer can choose other services based on personal preferences. For instance, customers can get a discount if they prepare their own cups, choose different sauces, and replace the meals ingredients. After the customer has finished the conformation, the customer continues by pushing on the submit button.

Step 4: Enter personal information and take the meals

After the customer has submitted the order, the APP ordering system will request the customer to enter personal information like name and phone number, in order to ensure that the customer can receive the dishes accurately. The system will give the customer an order number and information concerning how long the customer can have the meal. In, addition, the APP ordering system asks whether the customer would like to save this order in the record. In case, the customer would like to order the same combination of dishes another time without completing all the steps again.

IMPROVEMENTS OF THE APP ORDERING PROCESS

This section describes improvements of the general APP ordering process used in Taiwanese fast food restaurant chains. The improvements have been identified through applying the reengineering approaches found in the literature review on the APP ordering process. The analysis resulted in four suggested improvements, which are described in more detail below.

1. Add quick order process

Sometimes the customer is in a hurry and needs to be able to order quickly. This could be taken care of by adding a quick order process. Two functions could be added in the APP ordering system to provide two alternative quick order processes. The first function is an a la

carte menu with the main dishes. The a la carte menu should only show the main meals (e.g., a hamburger without the drink and french fries) and exclude catering and special meals with discounts. This will decrease the total ordering time for the customer. The second function is combo meals. The combo meals represent fixed combinations of meals that the customer can choose. This will also decrease the total ordering time for the customer.

2. Add dishes waiting/preparing time

When the customer decides what to order it could be helpful to know the individual waiting time of the different dishes. This could be taken care of by adding different colors the to dishes (i.e., picture or symbols) in the APP ordering system. For example, dishes with green symbols can be prepared soon, dishes with orange symbols will take some time to prepare, and dishes with red symbols will take a long time to prepare. In this way, the customers will know how long time they need to wait before it is possible to have the meal and may choose dishes based on this information.

3. Add meal suggestion function

Many customers have special demands when it comes to food. This could be taken care of by adding a function in the APP ordering system, which recommends different dishes, based on the customer's individual requirements. For example, customers that want to control their health or are dieting could be recommended dishes with fewer calories. In addition customers with allergies could be recommended dishes without certain ingredients.

4. Add map based location selection

The APP ordering system in fast food restaurants in Taiwan first allow the customer to select a restaurant site based on written information about the location. After a restaurant site has been selected, the location is shown on the map. The customer has to make an order on one page and view the map on another page. The APP ordering system from an enterprise in Japan instead shows the customer's relative position to restaurant sites on a map. The customer can also select a restaurant site directly on the map. This allows the customers to know the best restaurant location, even if they have no knowledge of available restaurant sites. The APP ordering system in Taiwan is less convenient and could be improved by adding the functions of seeing all restaurant sites on a map and the customer's relative position to them and the function of selecting restaurant site directly on the map. The customer should also be able to work on a single page. This will also decrease the total ordering time for the customer.

CONCLUSION

This paper describes a general APP ordering process used in Taiwanese fast food restaurant chains. The process has been developed, by using the APP ordering systems provided by different fast food restaurant chains in Taiwan. In addition, this paper describes four ways to improve the APP ordering process. The improvements have been identified through applying

reengineering approaches found in the literature on the APP ordering process. The suggested improvements include: (1) Add quick order process, (2), Add dishes waiting/preparing time, (3) Add meal suggestion function, and (4) Add map based restaurant location selection.

The customer will sometimes forget to pick-up the ordered meal due to some events. In order to avoid these situations, the APP ordering system can provide a reminder function (e.g., the customer's cellphone could ring, shake, blink, or receive a message from the APP ordering system) to remind the customer to pick-up the ordered meal. If the customer activate the reminder function, the APP ordering system will remind the customer in any of the above-mentioned manners, when the meal order is ready. This implies that the customer will have

REFERENCES

1. Ayalew, R. (2011) Consumer Behaviour in Apple's App Store, Master's Thesis in Human Computer Interaction, Uppsala University.
2. Chang, C.-C., Han, W.-C., & Chang, S.-S. (2003) A model of Customer Satisfaction with Service Failures, Customer Attribution and Service Recovery, Journal of Business Administration, 57, 129-162.
3. Chen, W. (2012) Cost and benefit model of function and quality investments about App, Department of Management Sciences Master's Thesis.
4. Cheng, M.-Y., Tsai, M.-H., & Sutan, W. (2009) Benchmarking-based process reengineering for construction management , Automation in Construction, 18(5), 605-623.
5. Cheng, C.-Y., Sun, T.-H., & Liu, J.-F. (2000) Establish production system of single window operation by re-engineering, Journal of Chaoyang University of Technology, Vol.5, 137-149.
6. Cortimiglia, M.N., Ghezzi, A. & Renga, F. (2011) Mobile Applications and Their Delivery Platforms, IT Professional, 13(5) 51-56.
7. Gao, F., Xiao, G., & Zhang, Y. (2007) Strategy and method of part reengineering, International Journal of Advanced Manufacturing Technology, 34(3/4), 219-226.
8. Geng, H., Chen, W.-B., & Huang, L.-H. (2009) E-Government Oriented Public Service Process Optimizing Method Study, Soft Science, 5(23), 37-41.
9. Hammer, M. & Champy J. (2006), Reengineering the Corporation: A Manifesto for Business Revolution, New York: Harper Business. Available at
10. Hsu, H.-P. (2013) A Research on the Requirements and the User Interface Design for the Elderly to Use Smartphone Apps – Take Health Information Apps as Example, Graduate School of Curriculum and Instructional Communications Technology Master's Thesis.
11. Kana (2013), KFC promote the ordering APP in British, Macao Daily News. Available at http://big5.chinanews.com:89/hb/2013/05-02/4781501.shtml. Retrieved 2014-03-16
12. King, W.R., & Teo, T.S.H. (1996) Key dimensions of facilitators and inhibitors for the strategic use of information technology, Journal of Management Information Systems, 12(4), 35-53.

13. Klein, M.M. (1993) IEs fill facilitator role in benchmarking operations to improve performance, Industrial Engineering, 25(9), 40-43.

14. Lai, W.-H., & Lee, H.-S. (2013) Analyzing the Waiting Time Perception by Using Flow Theory and Queue Model, East-Asia Review, Vol. 479, 65-84.

15. Lutz, A. (2013) McDonald's Is Testing A Mobile Ordering App, Business Insider. Available at http://www.businessinsider.com/mcdonalds-will-test-mobile-ordering-app-2013-9. Retrieved 2014-03-16

16. Parasuraman, A., Zeithaml, V.A., & Berry, L.L. (1991) Refinement and reassessment of the SERVQUAL scale, Journal of retailing, 67(4), 420-450.

17. Williams, A. (2013) Finger-tapping good: KFC trials iPhone app in London restaurants letting customers order and pay BEFORE they queue, Daily mail. Available at http://www.dailymail.co.uk/sciencetech/article-2303915/KFC-trials-iPhone-app-London-letting-customers-order-pay-BEFORE-queue.html. Retrieved 2014-03-16

18. Yang, J-.H. (2009) Walk into App store model, Science & Technology for China's Mass Media, 2009(4), 42-43.

EFFICIENCY AND ECONOMIC PERFORMANCE ASSESSMENT OF BIOGAS PLANTS

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ABSTRACT

Purpose: The aim of this paper is to analyze impact of biogas plant technology on financial and economical condition of enterprises using this technology and asses performance of the biogas plants sample. Moreover, this paper gives an overview of the current situation of biogas plants in Slovakia. In order to fulfill the goals the following hypothesis is formulated and reviewed: "It can be assumed that a project of biogas plant with guaranteed price subsidies of electricity is profitable for an enterprise".

Methodology: To analyze profitability of the projects, net present value (NPV) and internal rate of return (IRR) concepts are used as evaluation criteria. To find out the efficiency of biogas plants the data envelopment analysis (DEA) was undertaken. DEA is the tool generally used to evaluate the efficiency of decision making units.

Findings: There are 92 biogas plants in Slovakia with average installed capacity 996 kW. BGP with electric capacity of 1 MW needs annually 20 thousand tons of silage, which is an area of 500-600 ha. Currently BGPs need about 550 thousands of tons of corn silage which represents roughly 25 % of production and 21 thousands hectares of arable soil. In case of future building of BGPs in the same technological and structural pattern may lead into unreliable operations due to possible lack of input material or too high input costs. The new concept of Feed-In-Tariffs policy for electricity generated by biogas plants is supposed to stimulate biogas plants with lower installed capacity.

Originality/ Value: This research provides insights into performance of agricultural biogas plants in Slovakia and information that can be used as guidelines for legislation development and investors to support further expansion of biogas plants.

Keywords: biogas plants, biomass, efficiency, economic performance

A GA-AIS APPROACH TO MULTI-MOLD PRODUCTION SCHEDULING

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ABSTRACT

The optimization of production scheduling is very important nowadays since it directly affect the performance of manufacturing systems. In this paper, a novel evolutionary algorithm combining genetic algorithms (GAs) with artificial immune system (AIS) is proposed. It is applied to deal with the extended Production Scheduling with Mold Scheduling (PS-MS) problem that each job requires multi-mold operations. Five sets of hypothetical PS-MS problems are used for benchmarking with the objective of makespan minimization. Comparing the experimental results of GA and the proposed GA-AIS approaches, the proposed GA-AIS approach outperforms GA approach with better makespan and shorter computational time.

Keywords: Artificial immune system, genetic algorithm, production scheduling.

INTRODUCTION

With the competitive business environment, firms devoted enormous time and energy to increase their profitability. Production scheduling is one of the critical challenging issues. With good scheduling strategy, firms can optimize their production schedules leading to shortest makespan. In other words, the productivity will be improved. In the previous study (Wong *et al*., 2012a), a Production Scheduling with Mold Scheduling (PS-MS) problem was modeled to integrate machine and mold scheduling of plastics productions. As injection mold is an essential resource for plastics production, the availability of mold can seriously affect the productivity of the whole manufacturing system. Besides, the PS-MS model was extended for scheduling the jobs under die stamping operations environment (Wong *et al*., 2012b). Different from plastics production, each job for die stamping involves a series of operations. Each operation requires a specific mold installed on a machine. For example, a

job involves five operations. Five different molds should be prepared for the job. The PS-MS problem becomes more complicated and therefore a more efficient optimization methodology should be investigated.

Genetic Algorithms (GAs) is an evolutionary algorithm that is widely applied in many production scheduling problems. In the previous studies (Wong *et al*., 2012a & 2012b), a Genetic Algorithm with Dominant Gene (GADG) approach was proposed to solve the PS-MS problem. It is one of the advanced versions of GAs proposed by Chan *et al.* (2006) and has been successfully adopted in many scheduling problems. However, with the rapid increase in the use of GAs, there is not much room for improvement (Ge *et al.,* 2008; Samal *et al.*, 2014). The hybridization of GAs is likely to improve the quality of the solutions (Abraham and Grosan, 2007). Therefore, many researchers proposed hybrid approaches that integrated GAs with other evolutionary algorithms. Samal *et al.* (2014) proposed a GA based primary-backup fault-tolerant scheduling (PBFTS) approach incorporating the knowledge from the real-time task scheduling domain. Their results showed that the proposed hybrid approach outperformed other fault-tolerant scheduling approaches. Zhang *et al.* (2013) proposed a pareto-based genetic algorithm to tackle a multi-objective job shop scheduling problem. The proposed approach adopted a local search procedure to minimize three objectives in the given scheduling problems. Their results showed that adopting the local search procedure in GA could improve the overall efficiency of the entire algorithm. Sioud *et al.* (2012) proposed a hybrid genetic algorithm for a single machine scheduling problem with sequence-dependent setup times. They adopted a hybrid crossover (HIX) approach in GA. Their experiments demonstrated the proposed approach could improve several lower bounds of the given problem sets.

Artificial Immune System (AIS) is one of the evolutionary algorithms inspired by the biological immune system. Many applications for solving scheduling problems can be found in literature. For example, gencos wind–thermal scheduling (Lakshmi and Vasantharathna, 2014), maintenance scheduling (El-Sharkh, 2014), production scheduling (Al-Anzi, Allahverdi, 2013), RFID reader collision avoidance scheduling (Li and He, 2013) and project scheduling (Mobini *et al.,* 2011). Comparing with GA, the development of AIS for production scheduling issues is still in a relatively infant phase. However, in many cases, the metaphors of AIS can effectively eliminate some limitations existed in GA. It is encouraging that the adoption of AIS can improve the performance of GA. In this paper, therefore, a GA-AIS approach is applied to deal with the extended PS-MS problem identified by Wong *et al*. (2012b).

PROBLEM DESCRIPTION

The notation used in this paper is summarized as follows:

Indices

i:	Index of jobs, $i = 1, \ldots, I$;
r:	Index of operations, $r = 1, \ldots, E_i$, where E_i is the maximum operation of job i;
m:	Index of machines, $m = 1, \ldots, M$;
w:	Index of mold series, $w = 1, \ldots, W$;
w_k:	Index of molds, k is the number of operations of mold series w
t:	Index of time slots, $t = 1, \ldots T$;

Parameters

P_{irmw}:	Processing time of operation r of job i on machine m with mold w_r
S_{ir}:	Start time of operation r of job i
C_{ir}:	Completion time of operation r of job i
C_{max}:	Makespan of jobs

Decision Variables

X_{irmw}	= 1, if operation r of job i is allocated on machine m with mold w_r = 0, otherwise
Y_{irmwt}	= 1, if operation r of job i occupies time slot t on machine m with mold w_r = 0, otherwise

In this study, an extend Production Scheduling with Mold Scheduling (PS-MS) problem modeled by Wong *et al.* (2012b) will be solved by the proposed GA-AIS approach. The problem can be regarded as the production scheduling problem of die stamping in which each job requires more than one mold for operation. In the problem, there are I jobs, M machines and W series of molds. Each machine m spends P_{irmw} time unit to perform operation r of job i with mold w_r. It is assumed that I, E_i, M, W, w_k and P_{irmw} are given and known in advance. A production schedule of the problem (X_{irmw}, Y_{irmwt}) will be determined and the start time S_{ir} and the completion time C_{ir} will be calculated. The objective is to minimize the makespan as follows:

$$Objective: MIN\{C_{max}\} \tag{1}$$

The problem is subjected to the following constraints:

$$S_{ir} \quad C_{i(r\ 1)} (i = 1, 2, ..., I; r = 1, 2, ..., R) \tag{2}$$

Constraint (2) defines that each operation has to start after the completion of the prior operation.

$$C_{ir} \quad S_{ir} = \sum_{mw} X_{irmw} P_{irmw} (i = 1, 2, ..., I; r = 1, 2, ..., R) \tag{3}$$

Constraint (3) ensures that interruption is not allowed during job operation.

$$\sum_{mwt} Y_{irmwt} = \sum_{mw} X_{irmw} P_{irmw} \ (i = 1, 2, ..., I; r = 1, 2, ..., R) \tag{4}$$

Constraint (4) ensures the time slot occupied for an operation is equal to the predefined processing time.

$$\sum_{m} X_{irmw} = 1 (i = 1, 2, ..., I; r = 1, 2, ..., R; w = 1, 2, ..., W) \tag{5}$$

Constraint (5) defines that each operation must be allocated and performed on one machine only.

$$\sum_{m} Y_{irmwt} \quad 1 (i = 1, 2, ..., I; r = 1, 2, ..., R; w = 1, 2, ..., W; t = 1,2...,T) \tag{6}$$

Constraint (6) ensures that each operation cannot be allocated on more than one machine at each time.

$$\sum_{irw} Y_{irmwt} \quad 1 (m = 1, 2, ..., M; t = 1,2...,T) \tag{7}$$

Constraint (7) defines that all machines are not allocated to process more than one job at each time.

$$\sum_{im} Y_{irmwt} \quad 1 (w = 1, 2, ..., W; r = 1, 2, ..., R; t = 1,2...,T) \tag{8}$$

Constraint (8) defines that each mold cannot perform more than one operation at each time.

OPTIMIZATION METHODOLOGY

In this paper, a Genetic Algorithm with Artificial Immune System (GA-AIS) approach is proposed to solve the extended PS-MS problem. The mechanism of the proposed approach is expressed in the following steps.

Step 1: Encoding
For chromosome encoding, each gene is composed of three parameters, representing **M**achine, **J**ob, **O**peration (MJO). They indicate the machine allocation for operations of a specific job. For example, a chromosome [121-211-122-212] indicated that Operation 1 of Job 2 is the first task in Machine 1. At the same time, Operation 1 of Job 1 is performed by Machine 2. After that, Machine 1 will perform Operation 2 of Job 2 and Machine 2 will perform Operation 2 of Job 1.

Step 2: Generation of initial pool
The initial population is randomly generated at the beginning. In this study, the population size is kept at a constant value of ten. In other words, ten chromosomes are randomly generated in the initial pool. It is suitable for the hypothetical problem sets adopted in this study, in which 30 jobs, 3 machines and 5 mold series are existed in the problems.

Step 3: Calculation of the objective value and fitness value
In this study, the objective of the extended PS-MS problem is to minimize the makespan of all jobs. By employing Equation 1, the objective value of each chromosome can be calculated. In order to normalize the objective value into a convenient range, a fitness function is applied to all chromosomes as follow:

$$1 \quad \frac{V}{S}$$

, where V is the objective value of a chromosome and S is the sum of all objective values in the population.

Step 4: Selection of chromosomes
In the proposed approach, a list of chromosomes are selected by a roulette wheel selection mechanism, in which the fitter chromosomes with higher objective value will have higher opportunity to survive and be selected to form a new population pool.

Step 5: Proliferation of chromosomes
Proliferation is the idea from the mechanism of artificial immune system, in which the copies of anti-bodies (chromosomes) are generated according to the proliferation rate. In the proposed approach, ten copies of each selected chromosomes are created. They will undergo mutation process.

Step 6: Mutation of chromosomes
In mutation operation, all chromosomes in the pool, including the new generated copies, will undergo mutation procedure. Some genes will be randomly selected and exchanged in order to diversify the solutions in the pool.

Step 7: Generation of a new solution pool

After the completion of mutation operation, the objective value and fitness value of all chromosomes will be calculated. The roulette wheel selection procedure will again perform to formulate a new solution pool.

Step 8: Stopping condition

The GA-AIS procedure will stop once the predefined stopping condition is satisfied. In this study, the stopping condition is the maximum number of evolution, which is 6000 times of evolution.

Comparing the traditional GA and the proposed GA-AIS, the encoding of chromosomes and the calculation of fitness values are the same. However, their evolutionary search procedures are different. In GA, crossover and mutation operations are adopted to create new solutions. In GA-AIS, the evolutionary search is achieved by cloning and mutating the chromosomes. In addition, in GA, the selection of new chromosomes is performed in the phase that all new chromosomes are generated. In GA-AIS, a chromosome is tested for acceptance or rejection immediately after mutation operation.

NUMERICAL EXAMPLES

In this section, the performance of the traditional GA approach and the proposed GA-AIS approach are experimented. Five hypothetical datasets of the extended PS-MS problem are generated. Tables 1 and 2 show the dataset of Problem 1 as an example. In all datasets, there are 30 jobs that are waiting for production. The product type and production unit of each job are specified in Table 1. The operation time of each product type is presented in Table 2. Each product type can be manufactured by more than one mold. The operation time among different molds may not be the same. The machine with no operation time means that the machine cannot operate that specific mold.

Table 3 summarizes the computational results of the GA and GA-AIS approaches from five datasets. With the objective of makespan minimization, the best result out of ten run are obtained for each problem. The results show that the GA-AIS approach outperforms the GA approach with 0.3% to 1.3% improvement. The GA-AIS approach is able to find a better solution comparing with the GA approach. Table 4 presents the computational times for obtaining ten solutions for each problem. Both approaches can solve all the problems within five minutes. It is shown that the GA-AIS approach is faster than the GA approach. It can save about 1.4% to 10% of the computational times. As a result, it can be concluded that the proposed GA-AIS approach can obtain better solution with shorter computational time.

Table 1. Job details in Problem Set 1

Job	Product Type	Unit('000)
1	4	4
2	4	6
3	2	5
4	4	3
5	5	4
6	4	6
7	3	3
8	4	5
9	1	3
10	4	4
11	4	3
12	2	5
13	5	3
14	3	5
15	3	6
16	3	6
17	2	6
18	1	4
19	1	5
20	4	7
21	1	5
22	4	6
23	5	3
24	3	5
25	4	3
26	5	6
27	5	3
28	2	4
29	3	7
30	5	3

Table 2. Operation time of each product type in Problem Set 1

Product Type	Mold	Machine 1 (unit of time)	Machine 2 (unit of time)	Machine 3 (unit of time)
1	1		7	7
1	2		6	
1	3	7		7
2	1	3		3
2	2		9	
3	1	5		
3	2		3	3

Product Type	Mold	Machine 1 (unit of time)	Machine 2 (unit of time)	Machine 3 (unit of time)
3	3	6	6	
4	1	8	8	8
4	2	10	10	
4	3		4	4
4	4			5
5	1	4	4	
5	2	9		9

Table 3. Makespans obtained by GA and GA-AIS

Makespan Optimization

Problem Sets	GA (unit of time)	GA-AIS (unit of time)	Improvement (%)
Set 1	868	863	0.6
Set 2	1335	1331	0.3
Set 3	1342	1325	1.3
Set 4	1159	1155	0.3
Set 5	1631	1625	0.4

Table 4. Computational time of GA and GA-AIS

Computational Time

Problem Sets	GA (sec)	GA-AIS (sec)	Improvement (%)
Set 1	279	272	2.5
Set 2	281	275	2.1
Set 3	283	279	1.4
Set 4	299	269	10.0
Set 5	292	280	4.1

CONCLUSION

This study proposes a novel evolutionary algorithm named GA-AIS approach that combines genetic algorithms (GAs) with artificial immune system (AIS). To evaluate the performance of the approach, the extended Production Scheduling with Mold Scheduling (PS-MS) problem is adopted as a benchmarking problem with the objective of makespan minimization. The experimental results show that the proposed GA-AIS approach can obtain better solutions with less computational time comparing with the traditional GA approach. For future study, the GA-AIS approach can be adopted in other optimization problems such as flexible manufacturing system (FMS) scheduling and maintenance scheduling.

ACKNOWLEDGEMENT

REFERENCES

1. Abraham, A. and Grosan, C. (2007), "Hybrid evolutionary algorithms: methodologies, architectures, and reviews", *Studies in Computational Intelligence*, Vol 75, pp. 1-17.
2. Al-Anzi F.S. and Allahverdi A. (2013), "An artificial immune system heuristic for two-stage multi-machine assembly scheduling problem to minimize total completion time", *Journal of Manufacturing Systems Volume*, Vol. 32 No. 4, pp. 825-830.
3. Chan, F.T.S., Chung, S.H., Chan, L.Y., Finke, G. and Tiwari., M.K. (2006), "Solving distributed FMS scheduling problems subject to maintenance: Genetic algorithms approach", *Robotics and Computer Integrated Manufacturing*, Vol. 22 No. 5-6, pp. 493-504.
4. El-Sharkh M.Y. (2014), "Clonal selection algorithm for power generators maintenance scheduling", International Journal of Electrical Power & Energy Systems, Vol. 57, pp. 73-78.
5. Ge, H.W., Sun, L. Liang, Y.C. and Qian, F. (2008), "An Effective PSO and AIS-Based Hybrid IntelligentAlgorithm for Job-Shop Scheduling", *IEEE Transactions on Systems, Man, and Cybernetics—Part A: Systems And Humans*, Vol. 38 No. 2, pp. 358-368.
6. Lakshmi K. and Vasantharathna S. (2014), "Gencos wind–thermal scheduling problem using Artificial Immune System algorithm", *International Journal of Electrical Power & Energy Systems*, Vol 54, pp. 112-122.
7. Li, Z. and He, C. (2013), "Optimal scheduling-based RFID reader-to-reader collision avoidance method using artificial immune system", *Applied Soft Computing*, Vol. 13 No. 5, pp. 2557-2568.
8. Mobini M., Sowlati T. and Sokhansanj S. (2011), "An Artificial Immune Algorithm for the project scheduling problem under resource constraints", *Applied Soft Computing*, Vol. 11 No. 2, pp. 1975-1982.
9. Samal, A.K., Mall R. and Tripathy C. (2014), "Fault tolerant scheduling of hard real-time tasks on multiprocessor system using a hybrid genetic algorithm", *Swarm and Evolutionary Computation*, Vol 14, pp. 92-105.
10. Sioud, A., Gravel, M. and Gagne, C. (2012), "A hybrid genetic algorithm for the single machine scheduling problem with sequence-dependent setup times", *Computers & Operations Research*, Vol 39,No. 10, pp. 2415-2424.
11. Wong, C.S., Chan, F.T.S. and Chung, S.H. (2012a), A Genetic Algorithm Approach for Production Scheduling with Mold Maintenance Consideration, *International Journal of Production Research*, Vol. 50 No. 20, pp. 5683-5697.

12. Wong, C.S., Chan, F.T.S. and Chung, S.H. (2012b), Joint Scheduling Approach for Production-Maintenance Scheduling with Setup Constraints, *The 13th Asia Pacific Industrial Engineering and Management Systems Conference (APIEMS 2012)*, Patong Beach, Phuket, Thailand, December 2-5.

13. Zhang, R., Chang, P.C. and Wu, C. (2013), "A hybrid genetic algorithm for the job shop scheduling problem with practical considerations for manufacturing costs: Investigations motivated by vehicle production", *International Journal of Production Economics*, Vol 145 No. 1, pp. 38-52.

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THE IMPACTS OF PRICNG AND REPLENISHMENT POLICIES ON THE SALE OF PERISHABLE PRODUCTS

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ABSTRACT

Purpose: to lower down sub-fresh products' inventory level through two policies of discount-rate policy and replenishment policy.

Methodology: Two methods to carry out this study are Multionomial Logit (MNL) and simulation model.

Findings: The findings from our simulation models indicate that discount policy can effectively decrease the number of freshness milk. This result is consistent with previous research: Ferguson & Koenigsberg (2007), Tsiros & Heilman (2005) and Wee (1999). The results of our replenishment policy, however, go against the finding of Broekmeulen and Bakx (2010). On these ground, we conclude that discount police is the appreciate way to overcome the problem of perishable products' inventory.

Originality/value: (a) to provide retailers a principle to set up an appropriate discount rate on perishable products; (b) to suggest retailers conducting pricing strategy to successfully ease inventory pressure of perishable products.

Keywords: Perishable product; Replenishment policy; Discount policy, Multinomial Logit (MNL); Simulation model

INTRODUCTION

For most retailers, perishable products, such as vegetables, fruits and milk, are such important and profitable category. However perishable products are too hard to manage for retailers (Ilic, Staake, & Fleisch, 2008; Tsiros & Heilman, 2005; Van Woensel, Van Donselaar, Broekmeulen, & Fransoo, 2007; Wee, 1999) because these products are limited in their shelf

times, and having decreasing values and qualities overtime (Fortin, Goodwin, & Thomsen, 2009; Van Donselaar, van Woensel, Broekmeulen, & Fransoo, 2006). This kind of products is not causally sold out in a day, and they will be resold in the following days. The resold perishable products are called sub-fresh products. According to prior research, they indicated that most customers are prefer to purchase fresh products than sub-fresh products (Fortin et al., 2009; Tsiros & Heilman, 2005). Under the aforementioned circumstances, retailers must try hard to avoid high inventory level for sub-fresh products.

How do retailers overcome the inventory problem of sub-fresh product? Firstly, a number of studies aptly pointed out a key strategy -- offering discount on sub-fresh products (Ferguson & Koenigsberg, 2007; Tsiros & Heilman, 2005; Wee, 1999). While considerable attention has been paid to research issues on using mathematical models to get optimum prices or inventory levels, and customers' willing to pay prices on different expiration dates of sub-fresh products, literature on issue of sub-fresh products' acceptable discount rate of customer and retailer in simulation model has emerged slowly and in a more scattered way.

Moreover, another strategy is in-store replenishment policy. Several studies have examined that in-store replenishment timing and frequency could influence customer's choice (Schneider, 2009; Van Woensel et al., 2007; Wee, 1999). In addition, the finding of Broekmeulen and Bakx (2010) suggested that single batch, one of the in-store replenishment policies, could do better by reducing 3.6% cost and decreasing the situation of product last-in-first-out (LIFO) withdrawal than a full shelf replenishment policy could do. However, the use of in-store replenishment policies to solve problem of Taiwan's sub-fresh milk inventory as a research field has not been much explored.

No matter how many policies we conduct, the key to success is taking customer heterogeneity into consideration (Tsai, 2011; Fortin et al., 2009; Kopalle, Kannan, Boldt, & Arora, 2012; Miranda & Konya, 2006; Tsiros & Heilman, 2005). Tsai (2011) pointed out housewives prefer to purchase sub-fresh and discounted products, so that retailers can offer deep discount strategy for housewives, instead of for office staffs. Despite the announced importance of customer heterogeneity, few researchers have experimentally employed it into retailer's policies.

In light of these concerns, this article has one purpose: to lower down sub-fresh products' inventory level through the policies recommended by this research.

In view of the preceding research purpose, three issues that need to be resolved in this

regard are (a) how we can incorporate information of consumer heterogeneity into our two policies; (b) which level of discount rate offered by retailers is enough to attract customer to purchase sub-fresh products, and (c) do discount rate polices and replenishment policies successfully decrease inventory level of sub-fresh products.

METHODOLOGY

Two methods to carry out this study are Multionomial Logit (MNL) and Simulation Model.

Multionomial Logit (MNL) is one experimental design of stated preference method. There are two significant advantages of stated preference method. First, it can simulate presence and absence situation of customer purchase behaviors in stores. Besides, it takes customer heterogeneity into consideration, so that we will recognize what sort of key factors which differ from customer to customer will affect customers to choose alternatives, such as income levels, brand preferences, behavior characteristics, and so forth. Therefore we can get such proper information to draw up effective policies to overcome obstacles to reduce the inventory of sub-fresh products.

Although many parameters and absence situation have been included in MNL, the precise nature of dynamic of consumer behaviors has not been thoroughly delineated. For instance, in store site, there are four different brands of milk in each customer's choice set at first. After a customer buy the last one of brand A milk, there are only three different brands of milk left in the next customer's choice set. Hence, we must employ another research method, simulation model, to truly delineate the dynamic that customers' choice sets are implicated in each other.

To explore the research questions, the following phase are: (a) collecting parameters and information used in our simulation models through Multionomial Logit (MNL); (b) constructing customer's behavior in the simulation models.

Phase 1: Collect Simulation Parameters through Multinomial Logit
Choice Experiment Design (MNL) and Attributes

Choice experiments (CE) are widely recognized as a method to reveal preferences of people in different applications (Hensher et al., 2005; Louviere et al., 2000; Train, 2003). The basic idea of CE is that an individual derives and maximizes utility from the characteristics or attributes from the goods as such (Lancaster, 1996). Base on the Random Utility Theory (McFadden, 1974) and the characteristics theory of Lancaster (1996), the utility for an individual *n* derived from a choice between milk of different expiration dates alternatives *j* in a choice occasion *t* is divided into non-stochastic (V_{njt}) and stochastic component (ε_{njt}). The non- stochastic utility consists on its turn of a choice-specific utility component (X_{njt}) and individual-specific component (Z_{nk}). The Multinomial Logit (MNL) model is presented as a baseline specification.

$$U_{njt} = V_{njt} + \varepsilon_{njt}$$

Where

$$V_{njt} = \sum_{t=1}^{4} \beta \, X_{njt} + \sum_{k=1}^{12} \Delta_k \, Z_{nk} \qquad (1)$$

With *t* is the number of times the experiment is repeated to the same individual n (=4), *j* is the choice between milk of different expiration dates alternatives, β is the relative utility weight (part-worth utility) associated with the attribute, and *k* is the number of individual-specific variables. A widely used approach to estimate the regression coefficients $\theta \in (\beta, \delta)$ is the maximum likelihood estimation, which provides the value for coefficients that makes the observed results the most probable (given the model). The θ coefficients can be calculated by using log likelihood function as follows:

$$1\theta = \sum_{n=1}^{516} \sum_{j=1}^{4} \sum_{t=1}^{4} Y_{njt} \log(P_{njt})$$

Where

$$P_{njt} = \frac{\exp(V_{njt})}{\sum_{j \in M} \exp(V_{njt})} \qquad (2)$$

Where $Y_{njt} = 1$ if individual *n* chooses label alternative *j* containing *M* possible choices in *t*-th choice occasion, and $Y_{njt} = 0$ otherwise.

CE is typically framed in a manner that closely resembles actual purchase decisions (Louviere et al., 2000). An important advantage of the CE methodology, more specifically, the stated preference experimentation, is that it offers the possibility to analyze the valuation of new products with new attributes for which there is no revealed preference history. By allowing the consumers to value multiple attributes simultaneously, information of consumer heterogeneity and purchase possibility to each alternative of freshness milk are acquired. It is taking advantage of simulation and prediction for customers' purchase decisions in actual market site.

In MNL, we presume there are four milk alternatives. The four milk alternatives, two-day, three-day, five-day, and at least 7-day expiration milk, are composed with the following three choice-specific attributes in the experiment: brands of milk, discount rates on milk, and capacities of milk bottles. Further, these attributes are differentiated with four, three, and two attribute levels, respectively.

Other individual-specific parameters are divided in two categories. First, consumer characteristics include buying habit, buying frequency, buying timing, brand preference, and buying motivation. Second, consumer individual characteristics include gender, age, occupation, and number of family members. In total, there are 12 parameters added in the MNL models.

Source of Data

Our study adopts the data collected from Tsai who had conducted survey at W supermarket in Taiwan in 2011. All customers who had bought milk in W supermarket were invited to participate in the survey. In total, 129 completed surveys were returned and used for further data analysis. The total sample size was equal to 516 (129 participates multiplied with four choice tasks).

Results of the MNL Model

The results of our MNL model are shown in Table 1. With respect to overall fit, the model was found to be significant (likelihood ratio test yields a $p < 0.001$). In congruence with the standard economic theory, the effect of discount rates on utility was negative and significant indicating that discount rates increments significantly decreased consumer's utility for milk alternatives, and vice versa.

Therefore, the MNL assisted our study to filter out the following nine parameters which have significant influences on consumer's utility: discount rates, brand preference (especially

brand A), buying habit, buying motivation, buying frequency, buying time interval, age, occupation (especially housewife), and number of family members. Other parameters with no significant effects, such as gender, capacities of milk bottles, and income, indicated that consumer's utility would not be influenced by them. Therefore, we only carried these significant parameters into our simulation model.

Table 1 Results of the MNL model

Variable	Coefficient (*t*-value)
Alternative Specific Constants	
2-day freshness milk	----
3-day freshness milk	0.5748(2.198)
5-day freshness milk	1.5378(2.005)
Fresh milk(At least 7-day)	2.5829(2.749)
Generic Variable	
Discount rate	-0.0286(-1.698)
Brand of milk (Brand A)	0.5476 (3.396)
Buying habit (fixed buying habit)	0.8171 (2.668)
Buying timing	
Morning (6~12 a.m.)	2.8135(4.338)
Off work (16~20 p.m.)	0.8550 (2.581)
Evening (after 20 p.m.)	0.9469 (1.811)
Buying motivation (special-purpose trip)	0.6628(2.254)
Buying frequency (once at least two weeks)	0.8818(2.911)
Age (31~40 years old)	0.6172(1.942)
Occupation (housewife)	0.4909 (1.945)
Number of family member	-0.0943(-2.434)
Log-Likelihood value	
LL(0)	-715.3278
LL(m)	-607.6329
LL(β)	-576.6907
Sample size	516

Phase 2: Constructing the Customer Behavior Simulation Models

This study conducts a customer behavior simulation model through Simul8 software. This software has the advantage of using defined modules to easily build a model, containing an input data analyzer that fits raw data to the most appropriate statistical distribution, and producing extensive output reports (Lee & Lambert, 2007).

And we take customer behavior simulation model as the foundation to develop and examine the consequences of conducting two policies. The details of our customer behavior

simulation model are shown as follows.
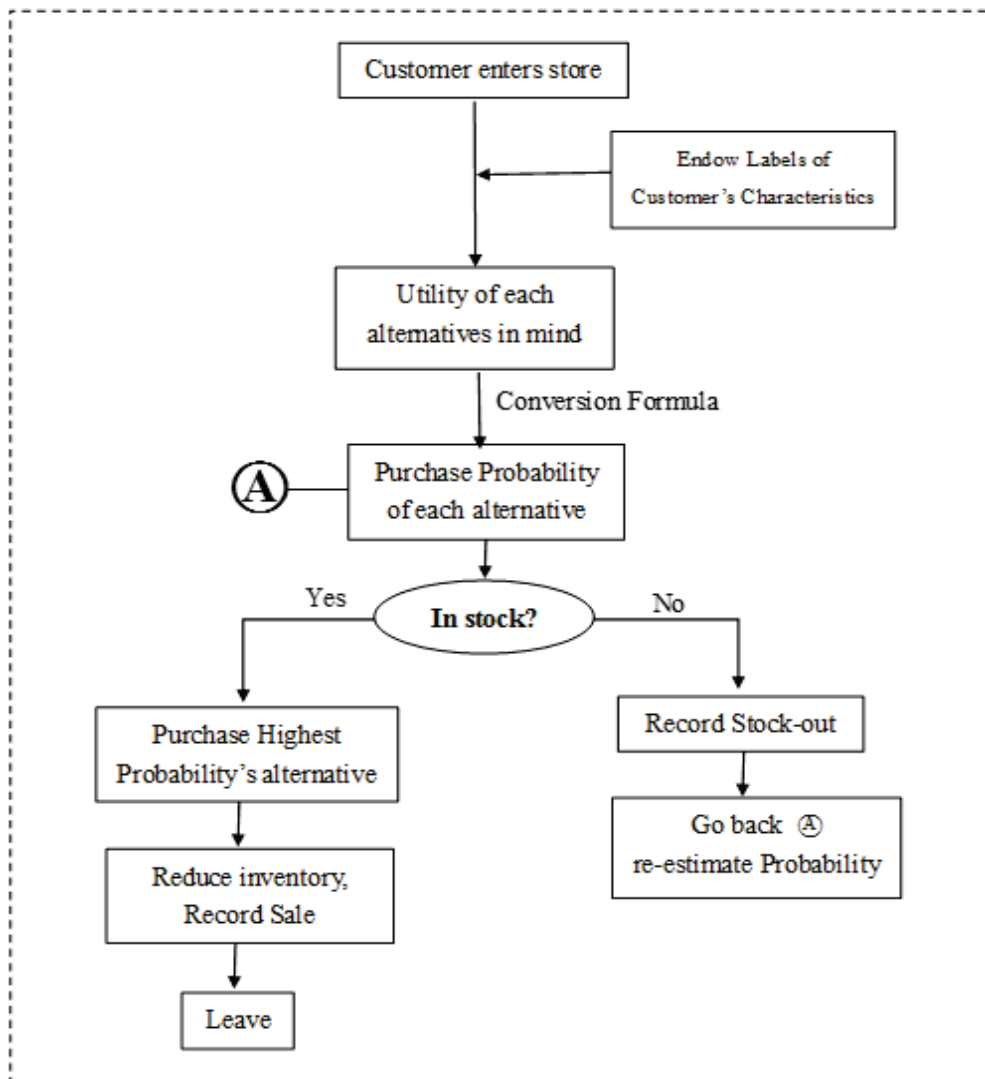
Figure 1 Customer behavior model

Customer Arrival Distribution and Simulation Time

In the simulation model, customers followed the logic described in Figure 1 to purchase their choices of milk, and the retail store adjusted its inventory level accordingly.

Computer simulation model had been developed to delineate customer's real behavior at a hypothetical retail store. The retail store operated from 6 a.m. to 22 p.m. daily in the simulation model. And the operation time was segmented to four time intervals, as morning (6-12 a.m.), afternoon (12-16 p.m.), off work (16-20 p.m.), and evening (after 20 p.m.).

The customer arrival data was collected for one month from 9 a.m. to 5 p.m. Monday to Friday by Tsai (2011) in the W supermarket. Peak operating hours were from 16:00 p.m. to 20:00 p.m. During Tsai's observations, it showed that the total number of customers was averagely fifty to sixty customers each day. Therefore, in this study, the customer arrival distribution was set as a Normal distribution with its average =50 and Std. =10.

This study set 129 visiting customers each day as a base scenario. And their arrivals in each time interval were specified according Tsai's (2011) survey data, as in Table 2.

Table 2：Percentage of arrival customers in each time interval

	Arrival time interval	Number of customers	Percentage
1	Morning (6-12 a.m.)	15	12%
2	Afternoon (12-16 p.m.)	16	12%
3	Off work (16-20 p.m.)	77	60%
4	Evening (after 20 p.m.)	21	16%
	Total	129 customers	100%

Customer's Characteristics

The nine parameters filtered by the previous MNL analysis were viewed as the main customer characteristics which significant influenced their utilities of milk purchase. For this reason, each customer which had arrived would be proportionally endued with the specific characteristics according to the statistical data from survey conducted by Tsai (2011). The detail information is shown in Table 3.

Table 3 Specifications of customer characteristics

Parameters	Category	Percentage
Age	31-40 years old	36%
	others	64%
Occupation (housewife)	housewife	25%
	other jobs	75%
Number of family member	1 member	5%
	2 members	16%
	3 members	22%

Parameters	Category	Percentage
	over 4 members	57%
Buying habit	fixed habit	80%
	no buying habit	20%
Buying motivation	special-purpose trip	42%
	not special-purpose trip	58%
Buying frequency	frequent buyer (once two weeks)	75%
	seldom buyer	25%
Brand preference	prefer Brand A	38%
	no specific brand preference	62%

Milk on Shelf

In the simulation model, we provide four kinds of milk all the same as the alternatives differentiated in the freshness levels of the MNL model, except for the brand of milk. As stated in the results of the MNL model, customer who had preference for brand A had priority to buy fresh milk in comparison to customer having no specific brand preferences. For this reason, we only offer two kinds of brands, brand A, and other Brand in the simulation model.

Customer Purchase Decision

Each customer would buy one bottle of milk before they left the simulation model. Their purchase decision-making process was using the MNL as a discipline. Take customer A for an example (see Table 4), when he arrived at the retail store, he had initial utilities for each kind of milk (calculating from formula 1). Then utilities would be brought into formula 2 to calculate purchase probability of each kind of milk. Finally, customer A would purchase fresh milk which was the highest purchase probability of alternative in choice set.

Table 4 The decision-making process of customer A

Alternative	Utility	Probability	Final choice
2-day freshness	$U(2)= -2.7257$	$P(2)=0.3653$	0
3-day freshness	$U(3)= -2.4361$	$P(3)=0.4370$	0
5-day freshness	$U(5)=0.3258$	$P(5)=0.2795$	0
Fresh milk	$U(7)=0.3908$	$P(7)=0.7205$	1

Policies

In this study, we develop two strategies to overcome the problem of sub-fresh milk inventory. Moreover, it is necessary to establish benchmarking policy to examine effectiveness of two strategies. Hence, there are totally three polices in our simulation model. And each policy includes two sub-policies. Table 5 lists all the policies.

Table 5 List of policies

Policy 0	Benchmarking Policy	0-1 Offer discount on sub-fresh milk
		0-2 Non-offer discount on sub-fresh milk
Policy 1	Replenishment Policy	1-1 Quantity of milk triggers replenishment
		1-2 Replenish, after sub-fresh milk sold out
Policy 2	Discount rate Policy	2-1 Offer deep discount on sub-fresh milk
		2-2 Offer light discount on sub-fresh milk

In the simulation model, these three polices are taking into account factors, such as customer behavior model, ordering system, daily stocktaking system, and in-store replenishment system. Later, we will describe the main ideas of the three policies in details.

Benchmarking Policy

In real site, Taiwan's retailers offer two different prices for sub-fresh milk. One is offering favorable prices on sub-fresh milk as a marketing strategy. Another one, generally used by most of Taiwan retailer, is not offering any discount on sub-fresh milk. Therefore, to delineate authentically retail stores operating, we build two benchmarking policies, Offer discount on sub-fresh milk (policy 0-1), and Non-offer discount on sub-fresh milk (policy 0-2). More contents of policies are showed in Table 6.

Table 6 Contents of the benchmarking policy

		Policy 0-1	Policy 0-2
Discount	2-day freshness	35% off	No discount on sub-fresh milk
	3-day freshness	25% off	
	5-day freshness	15% off	
	Fresh milk	No discount	
Replenishment system		■ Before the store run a business, clerks replenish fresh milk to shelf. ■ Each day, the retailer replenish fresh milk to shelf from its warehouse at 16:00 p.m. ■ The replenishment will stop until the shelf is filled to 60 bottles of milk.	
Daily stocktaking system		The retailer checks total inventory of milk. Total inventory includes milk on shelf and in its warehouse.	
Ordering system		■ Before the store run a business, every day the retailer decides whether to order fresh milk or not. ■ Order standard: when the total number of milk inventory is lower than 65 bottles, the retailer will place an order. ■ Order size: the maximum amount of fresh milk is 100 bottles.	

Replenishment Policy

Broekmeulen and Bakx (2010) addressed two in-store replenishment policies, Single Batch policy, and Full Shelf policy. The Single Batch policy limited the number of milk's freshness on the shelf to one. And the Full Shelf policy was that retailer only replenished the shelf if the inventory dropped to zero. The results of Broekmeulen and Bakx (2010) suggested that the Single Batch could do better than the Full Shelf replenishment policy on reducing 3.6% cost and decreasing the situation of product last-in-first-out (LIFO) withdrawal. Hence, in this study, we modify the Full Shelf policy to develop the policy of quantity of milk triggers replenishment (policy 1-1), and extend the Single Batch policy to apply in policy 1-2 (Replenish, after sub-fresh milk sold out). More contents of policies are showed in Table 7.

Table 7 Contents of the replenishment policy

		Policy 1-1	**Policy 1-2**
Discount	2-day freshness	Same as the policy 0-1.	
	3-day freshness		
	5-day freshness		
	Fresh milk		
Replenishment system		■ When the total number of milk on shelf is lower than 65 bottles, it triggers the retailer to replenish fresh milk from its warehouse. ■ The replenishment will stop until the shelf is filled to 60 bottles of milk.	When there is any sub-fresh milk on shelf, the retailer will not employ replenishment until sub-fresh milk sold out.
Daily stocktaking system		Same as the policy 0-1.	
Ordering system			

Discount-rate Policy

Tsai (2011) pointed out housewives prefer to purchase sub-fresh and discounted products, so that retailers can offer discount strategies to meet housewives' demand. On the other hand, customers with other occupations may not so care about the price of milk. To fulfill the demand of all customers and avoid offering discounts that are too deep to harm a retailer's profit at the same time, a retailer must find an acceptable discount for both sides. Hence, in this study, we develop two discount-rate policy, deep discount policy (policy 2-1) and light discount policy (policy 2-2), through adjusting the discount rates of the policy 0-1 to find out acceptable one. More details on discount policies are shown in Table 8.

Table 8 Contents of discount policy

		Policy 2-1	**Policy 2-2**
Discount	2-day freshness	40% off	30% off
	3-day freshness	30% off	20% off
	5-day freshness	20% off	10% off
	Fresh milk	No discount	No discount
Replenishment system		Same as the policy 0-1.	
Daily stocktaking system			
Ordering system			

RESULTS AND DISCUSSION

Before running the model, it is necessary to determine the required number of replications. The output performance is the average daily total inventory of sub-fresh milk in the system. The complete calculation is shown in the appendix. Initially 10 replications were used. The desired half width is set 12% of the mean. So by using the half width formula the number of replications needed to reach the desired half width is determined. Calculations show that 4 or more replications are needed in order to achieve the desired half width. This means the initial 10 replications are enough and no more replications are needed. Therefore, in our study we run total 10 replications.

	Fresh Milk	5-day freshness	3-day freshness	2-day freshness
Policy 0-1	67.73	10.36	0.06	0.02
Policy 0-2	68.00	10.08	0.05	0.01
Policy 1-1	64.09	13.53	0.28	0.10
Policy 1-2	64.91	12.67	0.26	0.08
Policy 2-1	67.09	10.91	0.00	0.00
Policy 2-2	67.21	10.82	0.00	0.00

Figure 2 Average bottles of milk sold each day

	Total INV	Fresh Milk	5-day freshness	3-day freshness	2-day freshness	Expired Milk
Policy 0-1	57.21	51.21	5.95	0.04	0.01	0.04
Policy 0-2	57.18	50.93	6.05	0.09	0.11	1.51
Policy 1-1	57.23	48.69	8.27	0.20	0.08	0.26
Policy 1-2	57.27	49.12	7.91	0.18	0.06	0.20
Policy 2-1	57.30	51.73	5.57	0.00	0.00	0.00
Policy 2-2	57.28	51.74	5.54	0.00	0.00	0.00
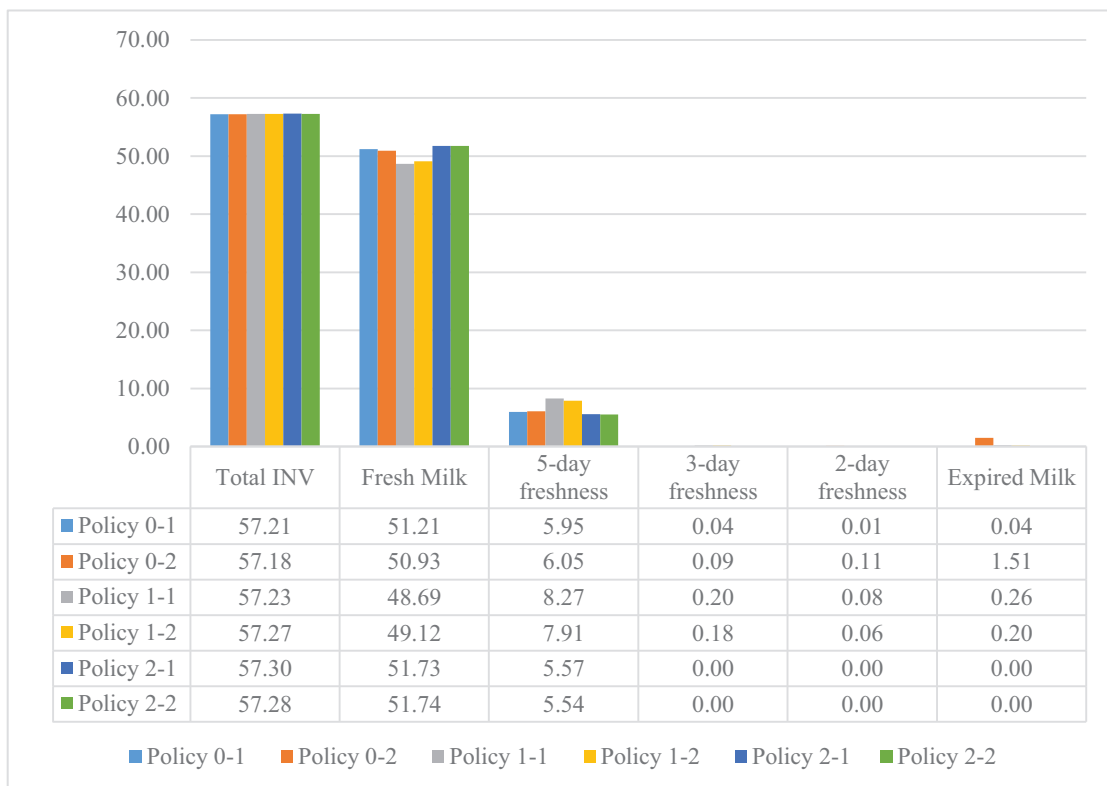
Figure 3 Average daily inventory of different freshness milk

Results of Discount-rate Policies

Figure 3 presents the result of our policies. When we do not offer any discount on sub-fresh milk (policy 0-2), it indirectly leads to average 1.51 bottles of expired milk each day. On the other hand, if we offer discount on sub-fresh milk as policies 0-1, 2-1, 2-2 do, the average daily inventory of expired milk drops to 0. This finding suggests that the discount rate policy may successfully decrease the inventory of sub-fresh milk.

Moreover, the results of the discount-rate policies show that no matter what levels of discount retailer offers, deep or light discount, customers are willing to buy the sub-fresh milk, in that policies 2-1 and 2-2 sold the same amount of bottles of sub-fresh milk. Therefore, in this research, offering deep or light discount does not significantly sell sub-fresh milk more quickly as we initially expected. But, discount policy is still working to ease the inventory pressure of sub-fresh milk. The last but most important finding is that retailers would not offer too deep discount rate to boost sub-fresh milk's selling.

Results of Replenishment Policies

The results of the replenishment policies indicates that the average daily inventory of sub-fresh milk from conducting policies 1-2 and 2-2 are higher than the benchmarking policy 0-1's. Figure 3 describes that five-day freshness milk's daily inventory in the policy 1-1 is averagely 8.27 bottles which is more than the 5.95 bottles in the policy 0-1. We propose two reasons why replenishment policies cannot lower the level of sub-fresh milk's inventory as we expected earlier in the followings.

Firstly, the policy 1-1 may directly cause the competition between fresh milk and sub-fresh milk. We find out that the replenished time is unfixable under employing the policy 1-1, after carefully checking the simulation model several times. Most of replenishments are conducted at the peak time (16-20 p.m.) when arriving customers are prior to buy fresh milk. So that if the retailer replenishes fresh milk to its shelf, the sub-fresh milk would lose some probability of being purchased by customers. Hence, the policy 1-1 apparently does not do very well on easing tension of sub-fresh milk's inventory.

Moreover, the policy 1-2 faces as the same situation as the policy 1-1 does, but in a different way. According to the main idea of the Single Batch policy, we expect that storing only one kind of freshness milk, especially sub-fresh milk, on the shelf, it would avoid the competition between fresh milk and sub-fresh milk. However, we dig out a phenomenon in the simulation model. The phenomenon is that it is impossible to limit one freshness milk on the shelf (Single Batch), and results from inconsistent command of two systems in the

simulation model. For instance, in the replenishment system, when there are sub-fresh milk on the shelf, the retailer would not conduct the replenishment policy. But the decision, not replenishing, will be broken by the daily stocktaking system. Under the daily stocktaking system, the retailer will regularly replenish fresh milk until there are total 60 bottles on the shelf, before they run a business. This inconsistent action leads our policy 1-2 fails to stick on the main idea of the Single Batch policy. For this reason, policy 1-2 apparently does not boost the sub-fresh milk's selling.

CONCLUSION

The main purpose of this present study is attempting to reduce the perishable products' inventory through two policies we suggested. Simulation modelling work has been undertaken to gain insights into the dynamic behavior of customer reactions to the policies of discount-rate and replenishment. The findings of simulation model indicates that discount policy can drop total number of expired milk. Up to this point, these results are consist with those of previous research (Ferguson & Koenigsberg, 2007; Tsiros & Heilman, 2005; Wee, 1999). The results of our replenishment policy, however, apparently does not do very well on easing tension of sub-fresh milk's inventory. This goes against the finding of Broekmeulen and Bakx (2010). On these ground, we have arrived at the conclusion that the discount policy is the appreciate way to overcome the problem of perishable products' inventory.

The findings of this study also have implications for the discount-rate policy. The present study enhances the previous research's findings of the discount policy by providing a much more detailed examination of discount rates through analysis of the MNL and simulation model. According to the results of policies 2-1 and 2-2, they indicate that retailers do not offer too deep discount rate to boost sub-fresh milk's selling in the condition of not harming profits. Therefore, the present study provides retailers a principle to set up an appropriate discount rate on sub-fresh product.

REFERENCE

1. Broekmeulen, R., & Bakx, C. (2010). In-store replenishment procedures for perishable inventory in a retail environment with handling costs and storage constraints.
2. Ferguson, M.E., & Koenigsberg, O. (2007). How should a firm manage deteriorating inventory? *Production and Opereations Management, 16*(3), 306-321.

3. Fortin, C., Goodwin, H., & Thomsen, M. (2009). Consumer attitudes toward freshness indicators on perishable food products. *Journal of Food Distribution Research, 40*(3), 1-15.

4. Hensher, D.A., Rose, J.M., & Greene, W.H. (2005). *Applied choice analysis: A primer*: Cambridge University Press.

5. Ilic, A., Staake, T., & Fleisch, E. (2008). The value of sensor information for the management of perishable goods–a simulation study: Working Paper, Information Management D-MTEC.

6. Kopalle, P.K., Kannan, P., Boldt, L.B., & Arora, N. (2012). The impact of household level heterogeneity in reference price effects on optimal retailer pricing policies. *Journal of Retailing, 88*(1), 102-114.

7. Lancaster, K.J. (1966). A new approach to consumer theory. *The journal of political economy*, 132-157.

8. Lee, K.W., & Lambert, C.U. (2006). Using simulation to manage waiting time in a cafeteria. *Information Technology in Hospitality, 4*(4), 127-141.

9. Louviere, J.J., Hensher, D.A., & Swait, J.D. (2000). *Stated choice methods: Analysis and applications*: Cambridge University Press.

10. McFadden, D. (1973). Conditional logit analysis of qualitative choice behavior.

11. Miranda, M.J., & Konya, L. (2006). Promoting brands of perishable items on the promise of generous availability of consumption time. *Journal of Targeting, Measurement and Analysis for Marketing, 14*(3), 238-248.

12. Schneider, M. (2009). Out of stock! Out of business?: The impact of unilever's delivery performance on final on shelf availability.

13. Train, K. (2009). *Discrete choice methods with simulation*: Cambridge university press.

14. Tsai, C.-C. (2011). *Customers' chioce behaviors on freshness pricing: The case of milk in the supermarket.*

15. Tsiros, M., & Heilman, C.M. (2005). The effect of expiration dates and perceived risk on purchasing behavior in grocery store perishable categories. *Journal of Marketing*, 114-129.

16. Van Donselaar, K., van Woensel, T., Broekmeulen, R., & Fransoo, J. (2006). Inventory control of perishables in supermarkets. *International Journal of Production Economics, 104*(2), 462-472.

17. Van Woensel, T., Van Donselaar, K., Broekmeulen, R., & Fransoo, J. (2007). Consumer responses to shelf out-of-stocks of perishable products. *International Journal of Physical Distribution & Logistics Management, 37*(9), 704-718.

18. Wee, H.-M. (1999). Deteriorating inventory model with quantity discount, pricing and partial backordering. *International Journal of Production Economics, 59*(1), 511-518.

APPENDIX

A1 Number of Replications

Run initial 10 replications, simulation gives the following results of total daily inventory (policy 0-1):

Mean = 57.21 bottles,

Standard deviation = 15.57 bottles

The half width formula is given as:

$$h_d = Z\alpha/2 \times S/sqrt(n_d)$$

Where h_d and n_d are desired half width and desired number of replications, respectively. The formula can be used to calculate desired number of replications once desired half width is known. Since we want to set desired half width at 12% of the mean.

So h_d will be 0.12×57.21 = 6.8652

Substitute the values in the equation results,

6.8652 = (1.96×15.57) / $sqrt(n_d)$

n_d= 4.4452.

So 4 or more replications will be required to achieve the desired half width.

A PROPOSAL FOR A TYPOLOGY OF LOYALTY SCHEME

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ABSTRACT

Loyalty scheme has existed over a century. A way array of businesses has been adopted it as part of business strategy, for example retail, airline. With the advancement of information system (IS), loyalty scheme has evolved into different levels and forms today. However, despite the popularities of loyalty scheme, it is less discussed in the literature on the perspective of loyalty scheme typologies as well as its association with informant system (IS). This study aims to discuss the definitions of loyalty scheme and propose a typology of loyalty scheme for practice use and further study.

Keyword: loyalty program, loyalty scheme, loyalty scheme typology, loyalty program typology

INTRODUCTION

Loyalty scheme has a long history. In 1896, the Sperry and Hutchinson (S&H) Company of the U.S., which began issuing S&H Green Stamps that year. In this stamps program model, customers would receive stamps at the checkout counters of retail store outlets. retailers, which could be redeemed for products in the catalog.

In the mid-1960's most gas stations and supermarkets were offering stamps to shoppers. At the peak of trading stamp popularity in the mid 1960's, S&H operated 800 free-standing redemption centers nationwide, and printed more stamps than the Postal Service (Slatalla 2000).

There is a similar phenomena in UK. A "Stamp War" broke out in 1963. Fine Fare, a British retailer, started giving away the American S&H Pink Stamps while other stamp companies competed aggressively for outlets, for example. Tesco was using Green Shied Stamps

In the 1970, Southwest Airlines ran a "Sweetheart Stamps" program that enabled travelers to collect proofs of purchase and exchange for free flights for their partners.

In 1981, loyalty scheme evolved into forms of Frequent Flyer Program (FFP) from Stamps program. American Airline's Advantage Program was an example that airline made a strategic decision to use its spare capacity as resource to generate customer loyalty. Since

then this basic model has migrated from airlines into many other B2C sectors such as : hotels, restaurants, retail, car hire, gas stations and bookstores (Buttle 2009).

The use of loyalty cards was an extremely important development in the 1990s in most developed world markets. Loyalty cards are now used in a number of sectors: retail, leisure, business airlines, car rental and more recently business-to-business markets (Tapp 2008).

Although loyalty scheme has gained its popularity in the past few decades as discussed in earlier paragraph, there is still not an universally agreed typology today. Merchants of different stage of growth face difficulties in understanding in the definition of a loyalty scheme, what it really is, and how many types of them.

The objective of this study aims to discuss the definitions of loyalty scheme and propose a typology of loyalty scheme for practice use and further study. This study reviewed and built upon prior literature about loyalty scheme definition and typologies to develop a new typology.

RESEARCH METHOD

Design science attempts to create things that server human purpose (Peffers et al 2007) and is fundamentally a problem-solving paradigm that seeks to create innovations that define the ideas, practices, or technical capabilities (Henver et al 2004). Design science research, therefore, is chosen for development of the artifact- typology.

This study follows DSRM process model proposed by Peffers et al (2007) to design this study. Peffers et al (2007) indicates that constructs, models, methods, instantiations, or new properties of technical, social, and/or informational resources are potential artifacts. This study believes typology fits this definition.
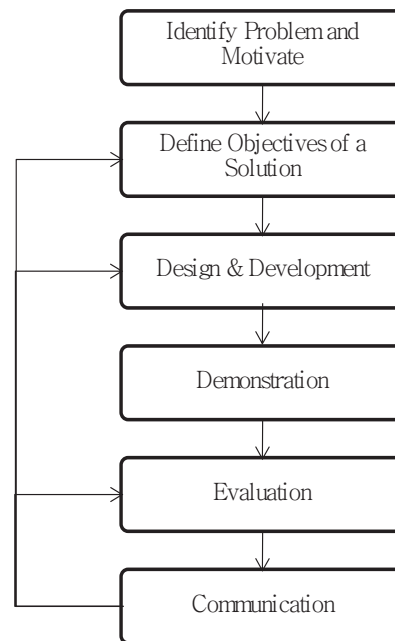
Figure 1 Design Science Research Process Model (Peffers et al. 2007)

This study has first conducted an intensive research review regarding loyal scheme types, including viewpoints of scholars from different continents. Next, prior research combined with current thoughts of own experience to develop a draft list of typologies. Final, the draft lists is furthered refined and developed based on   feedbacks from several industry managers to determine the appropriate typologies. A future full length journal article will provide more details of proposed typology including: a detailed description of each type; evidence and illustrations of organizations using them.

DEFINITION OF LOYALTY SCHEME

This study reviewed several different loyalty scheme literature (Rogers and Peppers 2011; Reinartz 2010; Buttle 2009; Liu and Yang 2009) and collective summary of loyalty definitions from Cao, Nsakanda, and Mann (2010).

There is not one single definition of a loyalty scheme because of its considerable overlap with promotional tools (Reinartz 2010); however, most scholars tend to view loyalty scheme as a reward program for repeated customers (Sharp and Sharp 1997; Lewis 2004; Berman 2006;Bagdoniene and Jaskstaite 2006; Sayman and Hock 2005; Liu and Yang 2009; Buttle 2009; Reinartz 2010 Pepper and Rogers 2011)

Banasiewicz (2005) highlights that IS aspect of a loyalty scheme. He indicates that a loyalty scheme can take advantage of rapid advancing information technologies to initiate marketing initiatives of finding and retaining brands' most profitable buyers.

Cao, Nsakanda and Mann (2010) pointed out an importance nature that a loyalty scheme play that is to require to collect customer information, and record customer purchase history, has a clear rewards scheme for repeated customer purchase behavior on the basis of customer purchase's history. They think the scheme should target a customer's long-term profitability or a customer life time value.

Based on prior research and drawn on important views from Banasiewicz (2005) and Cao, Nsakanda and Mann (2010), this study defines loyalty scheme as:

A scheme that collects customer information and purchase behaviors, leverages IS technologies to customize rewards for repeated customers so as to develop their long-term profitable loyalty.

TYPE OF LOYALTY SCHEME

There are many types of loyalty scheme existent in different forms on the markets. Based on earlier research from Cao, Nsakanda, and Mann (2010) who have reviewed three key literature on the classification of loyalty scheme, including Kadar and Kotanko (2009), Bagdonienė and Jakštaitė (2006) and Berman (2006), this study further review other related literature about this topic and includes Robinson (2011), Tapp (2009), Chang and Wu (2007) and in short list of classification of loyalty program.

Some scholars such as Berman (2006), Bagdonienė and Jakštaitė (2006), Chang and Wu's (2007), Tapps (2008), Kadar and Kotanko (2009) and Robinson (2011) have proposed different classifications of loyalty schemes respectively.

Based on the classification of loyalty programs from Tapp (2008), the first three type of loyalty scheme included by this study are: (1) proof of purchase based scheme; (2) card-based scheme; and (3) cross-category promotion scheme.

Besides, Chang and Wu (2007) introduced that retailers use two types of loyally schemes, depending on whether retailers co-operate with banks: (1) loyalty shopper card and co-branded credit card with banks.

Furthermore, other scholars looked at loyalty scheme typology from more tactical points of view (Berman 2006; Robinson 2011).
.
While there are several loyalty scheme classifications discussed in the aforementioned literature, this study found there are some overlapping on the types loyalty schemes and can be further consolidated. Next section presented will service this purpose.

A PROPOSED TYPOLOGY

Based on aforementioned research from Chang and Wu (2007), Tapp (2008), Braran, Galka, and Strunk (2008), Davenport and Harris (2007), Minami and Dawson (2008) ,Buttle (2009), and Robinson (2011), a new typology is presented as below.

1. Stamps Program

Loyalty scheme has a long history. In 1896, the Sperry and Hutchinson (S&H) Company of the U.S., which began issuing S&H Green Stamps that year. In this stamps program model, customers would receive stamps at the checkout counters of retail store outlets. retailers, which could be redeemed for products in the catalog.

This study found prior research seldom discuss or include it in the loyalty scheme classification. Since Stamps Program is the much earlier version of loyalty scheme and are still used by retailers today. For example, two major convenience chain store, 7-eleven and Family Mart still operates stamp programs as key tools to develop customer loyalty and customer traffics. This study believes it is important to include this very first loyalty scheme type into our typology.

2. Proof-of-purchase based loyalty scheme

Tapp (2008) indicated that some package goods manufacturers who cannot be easily use card still use this traditional mechanism. For example, manufacturers of drinks, such Vitalon Taiwan, allow customers to participate lucky draw competition after sending back with their profile as well as proof-of-purchase. This type of loyalty scheme enable manufacturers, bypassing retailers, to collect customer information such as names, or contact information with minimum cost.

3. Anonymous card-based scheme/ 4. Registered card-based scheme

Tapp (2008) thinks that card based schemes are ideal for tracking transaction data and building the customer records. Buttle (2009) further separates card-based programs into anonymous and non-anonymous programs based on whether loyalty card is anonymous or registered. Thus, this study takes viewpoints from Buttle's (2009) and includes two separated programs in the new typology of loyalty scheme. An anonymous program normally provides less customer information then registered card-based scheme.

5. Cross-category promotion scheme

Buttle (2009) identified "linked scheme" in his classification, which was defined as allowing different of retailers to join as participants and customers were able to convert their existing credits to the currency of linked scheme.

Tapp (2008) thinks that most loyalty schemes are run by single supplier which bears the cost of point reward and redemption. As a result, he found that "cross-category promotion

schemes" have become popular. This type of schemes normally involves a number of merchants from different sectors. Company not wanting to own a costly solo-run loyalty scheme can take advantage of "cross-category promotion scheme"

This study finds believes that "linked scheme" concept is similar to "cross-category promotion scheme" or "cross company program" of Kadar and Kotanko (2009). Loyalty scheme is not necessarily bonded with promotion although it is often seen so. To keep it simple and concise, this study uses "Cross-company loyalty scheme" as an umbrella term to represent this type.

6.   Co-branded Credit Card Scheme

This study agrees with Chang and Wu's (2007) to have an independent loyalty scheme type for "Co-branded credit card scheme" as it often engages one partner only, which is the bank. Chang and Wu's (2007) also found that co-branded credit card scheme was the most fast growing card type in the year of 2001 in Taiwan since retailers greatly adopted this type of loyalty scheme. In 2004, more than 50% of credit card growth came from co-branded credit cards.

7.   CRM-capable Loyalty Scheme

  It is worth noting that "customer relationship with frequent special offers", the scheme type four of Robinson's (2011) is the only loyalty scheme type discussed in prior research that addresses on integrating reward card into its customer relationship management system. thus it's CRM-capable. It is not uncommon to see a merchant that operates a loyalty scheme while has CRM system.

Robinson (2011) defines this type of scheme to run a full CRM system, including identifying customers by name and address, tracking all purchases, analyzing behavior and responding, which requires a substantial initial investment and an on-going commitment to fund the operation.

Evidences show that some retailers have already evolved into this stage, for example, Tesco, the third largest retailer in the world, has transformed its Clubcard loyalty program into different stages since 1995. Thanks to Dunnhumby, its data mining partner, Tesco now is capable of mining its data of over 15 millions member in UK, and develop a deeper relationship with each customer by using insight generated by data gathered to tailor offer to the needs and wants of their customers.

CONCLUSION AND LIMITATION

This study follows DSRM process model proposed by Peffers et al (2007) to design this study with an intensive literature review of prior research, including articles from renown journals, books, and secondary data from internet, as well as discussion and evaluation from

industry managers. Consequently, a typology of loyalty scheme is proposed, refined, and developed.

The purpose of this study is not only to assist loyalty marketing practitioners in better understanding the definition of loyalty scheme, but also to provide with a loyalty scheme typology as a discussion base for future researchers. Future works remain to be done to reflect the complexity and reality of loyalty scheme evolution in the industry.

REFERENCES

1. Baran, R., Galka, R., and Strunk, D. (2008), *Principle of Customer Relationship Management*, Thomson South-Western, Mason, Ohio.
2. Cao, Y. H., Nsakanda, A. L., and Mann, I. S. (2010), "A Typology Framework of Loyalty Reward Programs", *Communications in Computer and Information Science*, Volume 13, 159-170.
3. Drèze, X., and Nunes, J. C. (2009), "Feeling Superior: The Impact of Loyalty Program Structure on Consumers' Perceptions of Status", *Journal of Consumer Research*, Volume. 35 No. 6, pp. 890-905.
4. Buttle, F. (2009), *Customer Relationship Management- Concepts and Technologies,* Butterworth-Heinemann, Burlington, MA, USA
5. Frow, P., and Payne, A. (2009), "Customer Relationship Management: A Strategic Perspective", *Journal of Business Market Management*, Volume 3 No 1, pp. 7-27.
6. Gregor, W. T., and Friars, E. M. (1982), *Money Merchandising: Retail Revolution in Consumer Financial Service*, THE MAC Group, Cambridge, Massachusett.
7. Hevner, A., March, S., Park, J., and Ram, S. (2004), Design Science in Information System Research, *MIQ Quarterly,* Volume 28 No1, pp. 75
8. Liu, Y. P., and Yang, R. (2009), "Competing Loyalty Program: Impact of market Saturation, Market Share, and Category Expandability", *Journal of Marketing*, Vol. 73, pp. 93-108.
9. Krafft, M., and Ganesan, S. (2010), "CRM in Data-rich Multinational Retailing Environment: A Review and Future Research Direction", *Journal of Interactive Marketing*, 24, pp. 121-137.
10. Minami, C., and Dawson, J. (2008), "The CRM process in retail and service sector firms in Japan: Loyalty development and financial return", *Journal of Retailing and Consumer Services*, 15, pp. 375–385.
11. O'Guuinn, T. C., Allen, C. T., and Semenik R. J. (2006), *Advertising and Integrated Brand Promotion,* Thomson South-Western, 662, Mason, Ohio.
12. Peffers, K, Tuunanen, T, Rothenberge M, and Chatterjee S., "A Design Science Research Methodology for Information System Research, *Journal of Management Information System,* Volume 24, Issue 3, Winter, 2007-8, 45-78.
13. Peffers, K, Rothenberge M, Tuunanen, T, and Vaezi R. (2012), "Design Science Research Evaluation", *DESRIST,* LNCS 7286, pp.398-410.

14. Peter, J. P., and Olson, J. (2005), *Consumer Behavior & Marketing Strategy,* McGraw-Hill/Irwin, New York.

15. Sadasivan, K., Rajakumar, C. S., and Rajinikanth, R. (2011), "Role of Involvement and Loyalty in Predicting Customer's Purchase Intention towards Private Apparel Brand Extensions", *International Journal of Innovation, Management and Technology*, Volume. 2, (6).

16. Winer, R. S. (2001), "Customer Relationship Management: A Framework, Research Directions, and the Future", *California Management Review*, Volume 43 (Summer), pp. 89-105

17. Lonto, J. R. (2004), "The trading Stamp Story," studio z7 publishing, available at http://www.studioz7.com/stamps1.shtml

18. Sperry, and Hutchinson (2012), Sperry and Hutchinson Web Site, available at http://www.greenpoints.com/info/inf_aboutsh.asp

LEAN IMPLEMENTATION IN GERIATRIC CARE IN A MUNICIPAL: A CASE STUDY FROM SWEDEN

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ABSTRACT

Purpose: The aim of this research is to examine how lean has been implemented at geriatric care in a municipal department in Sweden, focusing on the experiences and challenges of the employees, together with the strengths and weaknesses of the lean philosophy.

Design/methodology/approach: The primary method used was a case study with interviews and observations on spot, in combination with a literature study. All with the intention of defining and describing lean, its value, and how organizations generally apply lean.

Findings: All sources of information have shown that there are many advantages with lean such as better communication and a better-organized workplace. In addition, lean tools help to eliminate non-value adding activities (waste). However, implementations also bring about issues and challenges such as the difficulty of creating a long lasting lean commitment. A lack of follow-ups and the decreasing demand for lean from the executives have been the main issues within the geriatric care. The next step might be to create a common organizational culture, which is permeated with continuous improvements, focusing on value-adding activities for the residents and others stakeholders.

Originality/value: Very few studies have addressed lean implementation in geriatric care as well as in a municipal department.

Keywords: Lean, continuous improvements, management, organizational development

Paper type: Case study

INTRODUCTION

Lean has been utilized mostly in the industrial sector (Keyte and Locher, 2008). Despite that, it can even be interpreted from different perspectives, depending on which profession one is in. Throughout the years, lean methods and tools have slowly spread to the public sector. The reason why lean has not been equally attractive in other sectors, for instance in the administrative sector, is due to the fact of complications of actually seeing *how* one can

implement this philosophy in a company (Breyfogle, 2007). The Toyota way of thinking has previously mainly been dominating in the manufacturing sector (Fillingham, 2007). Still, sectors such as healthcare and service have also been adapting lean to their work lately. The strategic adaptations of lean principles in healthcare have proven to be beneficial as they offer learning and growth opportunities (Ballé and Régnier, 2007).

The municipal of Borås in Sweden has recently stated to implement some Lean tools and methods. Two pilot projects of implementing lean were started in 2009 within the eldercare in the city of Borås, Sweden. The absence of common standards and goals at the different nursing homes, and a lack of continuity of improvement projects were becoming obvious. Consequently, the management was looking for a solution to the problems and discovered lean by coincidence, but decided to implement it in the organization. Two wards were chosen at two nursing homes for the pilot projects. It was soon extended to include a third ward, and by the end of the year at least one ward at each residential unit had enrolled on a lean crash course. The step from pilot projects to standard has also been taken since an adaptation of lean was used, after the municipal district where it first was implemented.

The main purpose of this article is to examine how lean has been implemented at geriatric care in a municipal department in Sweden, focusing on the experiences and challenges of the employees, together with the strengths and weaknesses that the lean philosophy involves. This issue has been examined through interviewing key managers and employees involved in the Lean pilot project. The remainder of this paper is structured as follows: To begin with, a literature review on issues related to Lean health care is presented in Section 2. After that the research method is presented in Section 3. Thereafter, the case is presented in Section 4 and 5. After that the case is analyzed and discussed in Section 5 and 6. Finally, the research is concluded in Section 8.

LITERATURE REVIEW

Lean can be described as "a systematic approach to identifying and eliminating waste through continuous improvement, flowing the product at the pull of the customer in pursuit of perfection" (NIST, 2000). When integrated into an organization, lean is a philosophy, which detects problems that are then minimized, optimized and recorded. Basically, it maps out the organization's networks of processes, documents them and points out the *whom*, *what*, *when*, and *how* (Fillingham, 2007). It is essential to detect the value aspect of lean in order to add or create value to the product or service, and to carry it out cost-effectively (Bicheno, 2004; Keyte and Locher, 2008; Hines and Rich, 1997).

The main idea of lean is to try to create value for the customer by eliminating as much waste as possible. This approach is a long-term objective where the interaction in the company itself plays a huge roll. The bottom line is all about using the company's resources in a better

way, requiring everyone to be on the same wavelength; because no one can do it all by himself, but everyone can do something (Larsson, 2008; Breyfogle, 2007).

The most essential step is to tackle the root of the problem "basic stability", examine it, and create a routine amongst the employees (Joosten et al., 2009). Check lists and standardized routines reduce the confusion between staff, encourages communication, and make the work flow with less mistakes (Chappel, 2002; Radnor and Walley, 2008; Joosten et al., 2009). Lean helps to eliminate waste in areas that has not been obvious before, with standardized procedures and routines. The positive aspects of adapting lean at nursing homes include; better communication between members of staff, a calmer working environment, and better awareness of responsibilities by mapping out to do lists for each day (Doerman, 2009; Roth, 2011). Nevertheless, implementing lean requires that everyone participates. Training is key, and an organizational culture of continuous improvements is needed as well. These conclusions are supported in literary texts such as the article Learning to Walk Before We Try to Run: Adapting Lean for the Public Sector by Radnor and Walley (2008). However, several challenges and problems have been identified in previous studies, including the staff members' unwillingness to change, the imperceptiveness of the management, the demand for increased efficiency, and a changing organizational policy (Bliss, 2008; Schiele, 2009). The management must provide support, proper training, and make a long-term commitment (Nash and Poling, 2007; Towne, 2010). Numerous studies show that training and communication is nessasarry (Towne, 2010; Schiele, 2009; Radnor and Walley, 2008; Schiele, 2009).

One of the main concerns of lean is sustainability (Jusko, 2010). Will the employees be able to keep up with the lean thinking, and not to forget to follow up on their progress? In order to make use of the full potential of lean, the staff must believe in the success of lean and develop a commitment to it (Losonci et al., 2011, Young and McClean, 2008). By doing so, the culture of lean will flourish naturally, waste will be eliminated, value will be created and a new beginning of optimized work will commence (Doerman, 2009).

RESEARCH APPROACH

The empirical data collection has been in the form of observations and interviews with executives and employees. Open interviews with a small number of key people were started. After that, four managers who participated in the pilot projects were chosen for the introduction. This was followed by three individual interviews with two head of units and the former operations manager. Thereafter, new interviewees were chosen among the employees at two nursing homes and at four different wards. The respondents were interviewed ward-wise and the questions posed varied between the different interviews, depending on the individual wards' situations. Each question was accompanied by a specific answer with certain keywords, and the respondents were given the opportunity to either agree with the answer or openly tell their side of the story. The type of interview that was used with the staff

can therefore be seen as a half structured interview, which is described as a cross between an open and a structured interview (Lantz, 2008).

CASE STUDY

In 2008, the management of the elderly care in the city of Borås was frequently discussing questions regarding *what* needed to be done to create a common ground for all members of staff, and *how* to create a common thread throughout the organization's improvement projects. The concept of lean was discovered by more coincidence and it was soon decided that the philosophy would be applied to the eldercare, leading to the development of the Brämhult model. The Deming cycle (Plan, Do, Check, and Act) was used as a foundation (Bergman and Klefsjö, 2003).

Plan

A training session for the management team was developed together with an external consultant who trained the managers. The training program included the lean game, value stream mapping and trips where the managers went out to the wards to observe the daily operations. Thus, the managers studied the process flow from their own perspectives. The purpose of the training was to get a glimpse of the value creation within the organization and also to identify the role of the employees.

Training session 1: A full day (24 hour) was inspected and instead of reviewing each staff separately, they decided to look at the whole ward's daily working process on an overall perspective.

Training session 2: It was then time to point out the difficulties and parts where improvements were needed. A desirable future scenario was created for six months ahead. The difficulties and problems were identified and analyzed, focusing on the basic concepts as flow, value and quality instead of just concentrating on the financials.

Training session 3: Post-it notes in different colors were placed along the process map of the daily activities (24 hour) with respective significance:
- **Green post-it**: Daily occurrences that work well in the organization.
- **Pink post-it**: Daily occurrences that should be inspected and then switched to green post-its.
- **Blue post-it**: Daily occurrences, for instance scheduled visits by nurses, therapists and doctors.
- **Yellow post-it**: Daily responsibilities that needed to be taken care of.

With the help of the post-it notes, the management could begin to process the course of events and eventually develop the desirable scenario, and an action plan was made. The employees started to work according to their specific directions with a maximum of three

improvements at a time. Different groups were appointed depending on where the improvements were taking place. The management team checked the improvements during each workplace meeting.

Do

During the management's training sessions with the consultant, it was eventually decided that two pilot projects would be started. The management selected a number of wards at different nursing homes to be included in the pilot projects. A training session about lean and continuous improvements was held before noon. The managers had the chance to develop their own ideas later on during the afternoon.

An example of how they implemented lean in the organization was at a nursing home for the elderly suffering from dementia. They had a storage space in the hallway that contained the basic ingredients often needed and used during the daily cooking sessions. At the same time they kept a cabinet in the kitchen with different items that were not used as much as the basic ingredients. The staff at the ward decided to move the basic ingredients to the cabinet in the kitchen instead, to be able to store them in a more ergonomic way. A calculation was made and it showed that they saved up to three and a half hours per week by relocating the items to the kitchen.

Another example is from another ward where they had a food trolley with coffee, tea, fruit etc. for the visiting relatives and staff. There was never a single person who had the responsibility for refilling the beverages and snacks. On the contrary, it turned out that everyone was in charge of the trolley. This resulted in all employees walking by the food trolley several times a day to check if anything needed a refill. Not only was this a waste of time, but it also increased the stress of constantly having to check on something. By using the lean philosophy, it was possible to think outside the box and see the entirety of the organization in a more detailed approach.

Check

Regular meetings at the workplace were used for follow-ups during the pilot projects. A noticeable phenomenon was that the motivation seemed to increase when the managers were present, making these meetings very important.

The lean process unfortunately came to a halt when new district managers, who did not know what lean was, were assigned in a reorganization in Borås. Preserving the knowledge of the managers who left their old positions would have been needed to ensure a lean progress, but that never happened. By doing so, the new managers would have had a clearer view of their tasks, and the opportunity to identify the main priorities. An important part of being a manager is to be able to coach and support the employees, follow up on progress, and create a good functional group process.

It was not until much later that managerial days were introduced, where about 90 managers from the entire district gathered for meetings. The point was to discuss the foundation of the managers' positions, their roles and contributions, and thereby making it clear what value actually meant.

Act

As the PDCA cycle is endless, the fourth step should be followed by the first step again to continuously try to improve the current situation, and thereby achieving the best results. The advantage with lean is that it can be applied daily. As the manager cannot always be present and participate in the daily working process it is important that the employees can be independent and still work towards the same goals. Time and effort have been put into these two pilot projects and training for both managers and employees. The goal was to create a standard with a thought surrounded by lean that would last continuously. It is in other words important to correct and improve the results that fell short of expectations, according to the PDCA cycle.

LEAN TOOLS AND METHODS USED

The purpose of implementing lean philosophy in the elderly care should be to try to eliminate all activities that do not benefit the patients (waste). In this case, an individual adaptation to the lean model was expected to contribute to a more qualitative work process.

There are several options to choose between when it comes to finding the right tools and alternative methods when working with lean. It is essential to implement a strategy that is tailored to the users and the staff so that the development does not create combats. The 5S was one of the tools that were selected for the eldercare. The 5S is a method used to create a standardized workplace, containing five basic steps to reduce waste (Larsson, 2008; Breyfogle, 2007):

1. **Sort** – An inventory is conducted in order to find out which processes and resources that exist within the organization. Unnecessary elements and objects that are not used daily are identified simultaneously as you thoroughly go through the operations and activities of the organization. Excess equipment is discarded or archived, so this empties up space and opens up the space available for other productive opportunities.
2. **Set in order** – In this step you organize the remaining items so that an effective layer is created. The equipment must be easily available and also marked where they should be located.
3. **Shine** – It is essential to conduct a thorough cleaning of the workplace in order to maintain the new improvements. A clean environment helps employees to stay focused and accountable. An efficient way to keep the cleaning is to introduce cleaning lists that are regularly updated.

4. **Standardize** – The workplace should be kept clean and organized, which requires continuous monitoring. This is accomplished by creating manuals, schedules or photographs to prevent proceedings from being broken down.

5. **Sustain** – Last part out of the five steps pertains to encourage and motivate staff to follow the instructions provided from the steps before. In order to be able to successfully implement the potential of 5S, discipline and commitment in the daily work chores are required. Administrative waste should at this stage decrease while fewer mistakes occur.

6.

The outcome of 5S will be an organized workplace with an optimized productivity. Using the 5S, one should be able to improve an organization without changing the current configuration (Larsson, 2008).

From this description of the model, it is clear that they have used the 5S within the eldercare in Borås. They have followed the instructions and checked the daily use of resources and sorted out the unnecessary items that add waste to the work process. This was done, for example, at one of the wards where items were relocated to a different storage cabinet where the usage was higher, resulting in a higher efficiency. Thus it falls into a natural change that alters the old routine and one starts to adapt to the new ergonomic way.

Gapp et al. (2008) points out that the 5S is a tool that is divided into two different parts. One part is the *way of working* that is required, and the other part is the *technique* used to achieve the requirements. This means that it is not enough to just know *what* to do, one must also know *how* to perform it. In this way it is possible to reduce both the big and small problems in the production flow. Thus it is not enough only to know what the 5S means as described earlier, one must also know *how* to locate and remove unnecessary items, *how* to limit and put aids in the necessary places, *how* to keep the workplace clean, *how* to follow up and create continuous activities, and *how* to keep this mindset alive.

The target of the Brämhult model has been to use various lean tools to improve working conditions and create a stable communication amongst staff. Once this has been achieved a relaxed environment for the residents of the nursing homes will be created. The model has been a springboard for many improvements since the implementation of lean, which include the following:

- Relocation of food supply
- Activity board
- Reporting standards
- Daily management
- Schedule adjustments
- Clothes labeling
- Washing standards

- Telephone hours

Even long term goals for the working environment have been developed, and are as follows:

- Structured meetings
- Welfare meetings
- Moving in standards
- Students and interns
- Order standards
- Arrival meetings

There are many tools in lean and it is extremely essential to select those that can improve the relationship between an organization and its customers. To be able to perform a value stream mapping and an analysis of problematic areas that provide non-value-adding elements, requires an awareness of and knowledge about what is considered to be waste within the organization. Another factor that may interfere with the process of creating value stream maps can be the lack of knowledge. If the knowledge is incorrect, incomplete or unavailable, it is likely that the administrative support process is not sufficient (Larsson, 2008).

Value-adding processes were developed while also differentiating between activities that were not value-adding but necessary, and non-value adding activities that could be reduced and eliminated. This indicates that they have also used the value stream mapping, and understood the importance of creating value.

ANALYSIS

When the pilot projects were initiated, there was a need for a common standardization within the eldercare. There was no common thread running through the organization, and improvement projects remained being projects, with a fixed beginning and end. An implementation of lean was hoped to be able to create continuity throughout the organization and its daily operations. The management was the first group of people to do a lean course, in order to ensure that the philosophy would become rooted into the foundations of the organization, creating a top to bottom stream. The implementation required a thorough evaluation of what was actually considered value-adding. From that point, it was easier to formulate common goals and in turn create that wanted thread running throughout the eldercare.

The wards all agree on one point – lean does help a lot when it comes to solving concrete problems, such as eliminating waste and unnecessary work. By showing all the activities of the week on a big whiteboard, all the days have become more structured as everyone has a better grasp of the daily chores and tasks, reducing stress among the employees. Also, unnecessary running and walking on the wards and a constant sense of unease have been heavily reduced, with each member of the staff knowing his or her responsibilities of the day. Even the communication has improved in this way. Now that it has been made clear *who*

needs to know *what*, and *when* this information is needed, everyone is clear on *how* the information should be passed forward. The results being a better working flow throughout the daily operations on the wards. So far, the wards that were involved in the pilot projects agree on the advantages of a lean implementation.

Even though the employees have been the driving forces behind the implementation, and more or less managed to change the attitudes on the respective wards, one has failed to create a new organizational culture within the eldercare. The synergy that lean could have generated has not been taken advantage of. Instead, the wards have individually been going through their lean journeys on their own and without much, if any, exchange of experiences with the other groups and wards. For this reason, it is easy to see big differences between the extent to which lean has been used and is still being used on the different wards, three years after the pilot projects started. The pilot wards were convinced about the advantages of being a part of the pilot projects though. It had the effect of unifying the staff in the quest for perfection, according to the lean philosophy. Something as simple as the management giving these wards more attention might have been a motivational factor to pursue the lean journey. A re-ignition is however needed in order to actively keep some wards' lean commitment.

The staff brought up, during several interviews, a wish of having managers that are more involved and supportive, especially during hard times when the results of the lean efforts have been difficult to spot. The support from the management has clearly decreased since the start, contradicting the initial idea, much because of some key figures being transferred to other parts of the organization when the municipality was restructured. Unfortunately, this happened when the pilot projects were still at a relatively early and vulnerable stage. The absence of a driving and motivating management reflects in the number of wards where the work with the lean approach has come to a halt. When the demand for lean declined, the responsibilities were all shifted to the employees and demanded them to realize the goals that were initially formulated by the management. The philosophy had not yet become rooted at some wards, where it has become difficult to achieve a self-sufficient lean organization.

The general view on the wards that have failed to integrate lean into their daily work is that lean is a subproject. It has therefore become something that is not prioritized just because "other things get in the way". Like a vicious cycle, lean remains an even lower priority with the lack of demand for it from the management, and the result of this is easy to guess. However, the interviewees all agreed that lean definitely was a real eye-opener at the start, when it came to examining the own ward's daily operations. Lean is still present at the back of many employees' minds, the difficulty is to deal with the identifying of waste and issues, and dare to take the first step and make the necessary changes. Another lacking aspect on the wards that have been visited during the study is a better and clearer system of following up on the efforts and changes that have been made. Both a follow-up on the wards' lean journeys where progresses and developments are being evaluated and discussed, as well as a follow-up

on the individual improvements that are made, are needed. In that way, it becomes clearer what has actually been accomplished and it proves the positive effects of lean.

It was basically impossible to talk about follow-ups during the interviews with the employees, because there simply were none anymore, in comparison to the workplace meetings held in the past during the pilot projects. The only method used by some of the wards as some kind of follow-up, was that the changes that had not been satisfactory or given the wanted outcome would sooner or later come up for discussion again. There are clear disagreements about the views on the effort that is being made on following up on the lean progress. The employees barely know of any occurrences when their progress has been considered, or when they have been given the opportunity to share their experiences with other wards. While on the other hand, the managers claim that it is done regularly, indicating that they think the reality is better than it actually is.

DISCUSSION

Firstly, it should be emphasized that the attitudes to lean differ quite a bit on the different wards that were included in this study. Similarly, there are big differences to what extent the lean philosophy has been applied to the daily work. Now the question is whether the attitude affects the extent to which lean has been used, or if the lack of visible and tangible results has made some wards bring their lean approach to a halt. It is possibly a lack of understanding for the philosophy that essentially causes these problems. It can be difficult to even see the advantages and applications of lean to eldercare, given that lean initially originated from the industry. What one strives to achieve with a lean approach is not necessarily huge improvements and changes, but small steps toward eliminating waste, and what is perceived to be non-value adding for the customers, or in this case the residents, in order to reach perfection. In other words, lean can bring about major improvements, but the means of achieving these big improvements are small and simple.

An organizational culture, which encourages continuous improvements, is needed to ensure that development is being sought after and pushed through. Revaluating the foundations of an organization is clearly a massive challenge, and definitely not something that is done over a day. Lean is a long-term undertaking, which requires full commitment, and the heavy work must therefore begin at the top of the organizational hierarchy. Even though the lean implementation in Borås started off with the management, the employees must ultimately believe in and understand the philosophy themselves. In this case, there has only been a short and intensive crash course, carried out like a one-time occurrence. It requires fully committed managers to provide the right training and guidance when needed, if the goal is to eventually have members of staff that can regularly push through changes on their own. The employees carry the responsibility of ensuring that progress is made and keeping the lean approach alive, while the management provides the appropriate tools. The management should be able to gradually reduce its involvement while the presence remains, without deteriorating the

quality of the work that is completed. Many of the key people in Borås were transferred to other parts of the organization relatively sudden, and neither the wards nor the Brämhult model, which was not yet fully developed, were ready for it. As mentioned, a lean implementation does not only demand a lot from the management. Since one strives for independent personnel that can keep the lean progress alive, it also makes great demands on each of the individual employees, and for the group dynamics among the staff on the wards to work out without disturbances. The chemistry between the employees has seemingly not been a problem on the wards that were studied and interviewed.

One of the earliest stages of the Brämhult model included the elimination of waste, i.e. what is not value-adding for the residents. The problem is that the definition of what *value* actually is differs from person to person. It is not always possible to know what each individual resident wants or needs, but to start a lean journey by profoundly discussing value and value-adding on the wards could be wise. In that way, the employees get an opportunity to examine what it is that they actually do every day, and what this leads to. The lack of regular follow-ups on the lean progress after the pilot projects have most likely caused the inspiration and motivation to work with the new approach to decline on some of the wards. It is easy to overlook the importance of what is being done when one does not see what is being achieved. A lean implementation, like any other change, requires a lot of time, commitment, and patience. In turn, it requires injections of motivation along the way and something as simple as following up on the efforts made, can easily generate this type of drive. One possibility would be to arrange gatherings where the different wards get to share their experiences and useful tips. While interviewing the staff, it was obvious that no such systematic procedure existed since it was not demanded from the management. Instead, the responsibility of keeping themselves inspired, motivated, and following up on their own work, have all been put on the employees themselves. The response of the managers was however different, as they claimed that a follow-up was a matter of routine during the workplace meetings. Also, exchanging experiences was always possible during meetings where representatives from each nursing home were present.

The badly timed restructuring of the organization in Borås clearly shows an absence of an organizational culture of continuous improvements. Lean happened to initially be thought of as the solution to this exact issue, but the situation remains the same today. Even though the driving managers have continued with the lean philosophy elsewhere after the restructuring, which of course is not bad in itself, it indicates that the managers overlooked another important aspect of lean – the holistic point of view.

What remains now is once again to formulate common goals and to create a standardized approach. As previous studies have shown, one of the positive outcomes of implementing lean includes the fact that a quality culture emerges when value-adding is the starting point. Unfortunately, this stage has not been reached yet in Borås, but in agreement with other studies, lean has contributed to a much improved communication flow at the wards, as well

as given a better grasp of the daily activities. In that sense, they have managed to achieve a better working environment. Simple but yet effective solutions are wanted, since it should not be difficult or troublesome to satisfy the residents. They are after all the reason for the existence of the eldercare.

Briefly, lean is not necessarily about big and drastic changes, but it requires the right foundation, in other words an organizational culture permeated with continuous improvements with the purpose of creating value for the residents, i.e. the customers. Keeping a holistic view is vital since each ward is a part of the chain that makes up the whole organization. A successful implementation of lean occur when driving leaders and managers regularly follow up on the work and efforts that are being made, provide support and encouragement, as well as solid and regular training. This paves the way for a culture of systematic development.

CONCLUDING REMARKS

The implementation of the lean philosophy contributed first and foremost to a better work flow at the wards. Activity boards were used to structure the days and helped to create a clearer picture of responsibilities and activities, reducing stress among the employees. For example, a food storage was moved and saved the staff an immense amount of time and running across the facilities. Lean worked as an eye-opener where the staff suddenly realized and saw much of the waste throughout the daily operations. All sources of information have shown that there are many advantages with lean such as better communication and a better-organized workplace. In addition, lean tools help to eliminate non-value adding activities (waste). However, implementations also bring about issues and challenges such as the difficulty of creating a long lasting lean commitment. A lack of follow-ups and the decreasing demand for lean from the executives have been the main issues within the geriatric care. The next step might be to create a common organizational culture, which is permeated with continuous improvements, focusing on value-adding activities for the residents and others stakeholders. By doing so, the organization will have a clear vision and philosophy, which makes it less vulnerable with time when certain key people are no longer in the organization. It is by looking back on the initial pilot projects that lessons can be learnt, and development can be achieved.

REFERENCES

1. Bálle, M., & Régnier, A. (2007) Lean as a learning system in a hospital ward, Leadership in Health Services, 20(1), 33-41.
2. Bergman, B., & Klefsjö, B. (2003), Quality: from customer needs to customer satisfaction. Lund: Studentlitteratur.
3. Bicheno, J. (2004) The new lean toolbox: towards fast, flexible flow. Buckingham: PICSIE Books.

4. Bliss, D. (2008) Lean in Healthcare—Wow, Frontiers of health service management, 20(1), 39-42.

5. Breyfogle, F.W. (2007) Lean Tools That Improve Processes: An overview, BPTrends, March 2007.

6. Chappel, L. (2002) Lean culture takes commitment, Automobile News, Vol. 76.

7. Doerman, S. (2009) Finding value in lean: Mapping your company's way through difficult times, Industrial Engineer, 41(8), 31-33.

8. Fillingham, D. (2007) Can lean save lives?, Leadership in Health Services, 20(4), 231-241.

9. Gapp, R., Fisher, R., & Kobayashi, K. (2008) Implementing 5S within a Japanese context: an integrated management system, Management Decision, 46(4), 565-579.

10. Hines, P., & Rich, N. (1997) The seven value stream mapping tools, International Journal of Operations & Production Management, 17(1), 46-64.

11. Joosten, T., Bongers, I., & Janssen, R. (2009) Application of lean thinking to health care: issues and observations, International Journal for Quality in Health Care, 21(5), 341–347.

12. Jusko, J. (2010) Lean Confusion, Industry Week, 259(9), 32-34.

13. Keyte, B., & Locher, D. (2008) Lean handboken: Värdeflödeskartläggning inom administration, tjänster och service. Stockholm: Liber AB.

14. Lantz, A. (2008) Intervjumetod. Lund: Studentlitteratur.

15. Larsson, L. (2008) Lean Administration: Konsten att införa och praktisera Lean i administrativa stödprocesser. Stockholm: Liber AB.

16. Losonci, D., Demeter, K., & Jenei, I. (2011) Factors influencing employee perceptions in lean transformations, International Journal of Production Economics, 131(1), 30–43.

17. Nash, M., & Poling, R.S. (2007) Strategic management of lean, Quality Magazine, 46(4), 46-49.

18. NIST (2000) National Institute of Standards and Technology: Principles of Lean Manufacturing with Live Simulation, Manufacturing Extension Partnership. Gaithersburg: MD.

19. Radnor, Z., & Walley, P. (2008) Learning to Walk Before We Try to Run: Adapting Lean for the Public Sector, Public Money & Management, 28(1), 13-20.

20. Roth, G. (2011) Sustaining Lean Transformation: Through Growth and Positive Organizational Change, Journal of Enterprise Transformation, 1(2), 119-146.

21. Schiele, J. J. (2009) Lean Thinking, The official publication of NIGP, pp. 10-12.

22. Towne, J. (2010) Lean Transformations: Planning a 'Lean' health care makeover", Health facilities management, 23(10), 51-54.

23. Young, T.P., & McClean, S.I. (2008) A critical look at Lean Thinking in healthcare, Qual Saf Health Care, Vol. 17, 382-386.

THE REASONS FOR CONTINUANCE INTENTION AMONGST FACEBOOK CHECK-IN SERVICE USERS

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ABSTRACT

Purpose: *Facebook services which allow users to check in at places and broadcast their location to peers have gained attention recently. However, little is known about why people continue to use check-in service. This study attempted to develop an integrated model applicable for use within the social network context. The analysis revealed that the proposed theoretical model provided an in-depth understanding of users' continuance intention toward Facebook check-in services.*

Design/methodology/approach: *Based on expectation confirmation theory and related technology adoption literatures, this study considered perceived usefulness, perceived playfulness, confirmation, satisfaction, and social norms as the determinants of continuance intention to use check-in services. The proposed model was empirically evaluated using randomized survey data collected from 222 users.*

Findings: *The results revealed that the direct path between perceived usefulness to continuance intention and satisfaction was insignificant and perceived playfulness had a significant influence on satisfaction and continuance intention. Privacy concern does not seem to influence the direct path between satisfaction and continuance intention. In addition, the results revealed that users' satisfaction not only was influenced by confirmation but also by perceived playfulness.*

Originality/value: *The paper verifies the effect of satisfaction, confirmation, perceived usefulness, perceived playfulness, and social norms on the continuance intention of check-in services users. Privacy concern does not seem to influence the direct path between*

satisfaction and continuance intention in a check-in service context.

Keywords: Expectation Confirmation Theory, Privacy Concern, Check-in Services, Continuance Intention, Social Network Sites (SNSs), Facebook, Location-Based Services (LBS).

Paper type: Research paper

INTRODUCTION

The recent growth in smartphones and global positioning systems technology has facilitated new forms of social interaction. The convergence of applications has bridged users' physical and social worlds. Location based services (LBS) are defined as services or applications that extend spatial information processing or geographic information capabilities to users via the internet or wireless network (Koeppel, 2000). Facebook check-in services with embedded LBS features were launched on August 10, 2010. Once you have checked in to a location, Facebook posts this information to your profile page and news feed. The application also prompts you to tag the Facebook friends who are with you and find other Facebook users at the same place. If you cannot find the correct check-in location from the list of available places nearby when you log in to the application, make your own Facebook (Adrian, 2010). Places check-in location like most features of Facebook, the social aspect of the places feature is a primary reason to use it. When a person checks in with Places, she is telling her friends where she is and, in many cases, what she is doing. She might be at a concert, visiting a local pub or walking her dog in the park. This is an easy way for faraway friends to see what that person is doing at that moment (Thayer, 2010).

While initial acceptance of information system (IS) is an important preliminary step toward realizing IS success, user's continued use of IS will account for its eventual success (Thompson, 2009). An empirical support for the impact of continued usage also show that increasing customer retention rate by 5 percent could decrease cost and increase profile 25-95 percent (Reichheld and Schefter, 2000). In recent years, Bhattacherjee's IS continuance intention model has been partially extended and applied to a wide range of studies which covered online banking (Bhattacherjee, 2001), web portals (Lin et al., 2005), e-learning systems (Limayem and Cheung, 2008) and online services (Limayem et al., 2007). Privacy issues, quality of LBS, and lack of cognition of LBS were all identified as the main barriers to LBS adoption and continuance intention (e.g., Chang et al., 2007; May et al., 2007). To our knowledge, few studies have investigated Facebook check-in continuance intention.

Therefore, this research intends to apply the expectation confirmation model to enhance the understanding of an individual's continuance intention behavior in Facebook check-in services. Although previous empirical studies (Bhattacherjee, 2001; Limayem, and Cheung, 2008) on IS continuance have shown that ECM is a rigorous model that determinate the IS continuance intention, IS continuance can be affected by factors not addressed by ECM. Perceived playfulness represents an intrinsic type of motivation, and several works in IS have confirmed the significant effect intrinsic motivation has on shaping the continued use of hedonic IS (Kim and Han, 2009). The unified theory of acceptance and the use of a technology model recognize social norm as a key element in intention to use IS. In particular, since check-in services are generally used in social contexts, the inclusion of social norms, such as interpersonal influence and external influence, seems to be warranted. We believe that in the context of Internet applications, measures of subjective norm should consider influence from interpersonal as well as external (Hsu and Chiu, 2004). Thus, a theoretical model integrating the intrinsic type of motivation, perceived playfulness, and social norm as well as ECM is developed here to investigate the key factors of Facebook check-in services continuance intention determinants. Privacy concern has attenuated the link between satisfaction and continuance intention in previous studies, and as such will be placed as a moderator in this study in order to evaluate its impact. We hope the research will illuminate the continuance intention of Facebook check-in service users.

THEORETIC BACKGROUND AND RESEARCH MODEL

On the basis of the expectation-confirmation model and behavior theory, this paper proposes a research model as shown in Fig. 1. The operational definitions of variables are listed in Table 1. The theoretical basis of each hypothesis will be described as follows.
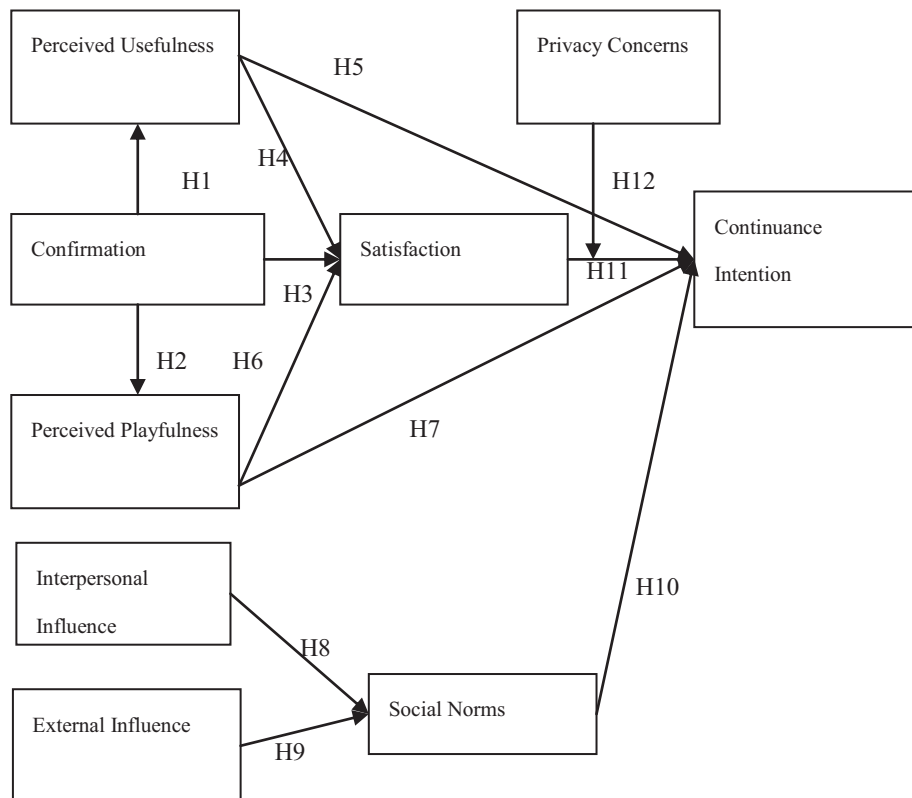
Figure 1   The research model and hypotheses

Expectation-confirmation Model

The Expectation Confirmation Model (ECM), derived from Adaptation Level Theory (ALT), has been widely used in the consumer behavior literature to study consumer satisfaction, post-purchase behavior (e.g., repurchase, complaints), and service marketing outcomes. Bhattacherjee (2001) developed and tested an ECM of continued information technology (IT) usage to explore users' continued IT usage decisions by analogy to users' repeat purchase decision. A user's satisfaction has a positive influence on his/her intention to continue usage of an IT. In some literatures, a consumer's level of satisfaction is the major factor for the consumer's decision to re-purchase products or patronize services (Oliver, 1993; Szymanski and Henard, 2001). A user's levels of confirmation and perceived usefulness are two key determinants of satisfaction, further determining continuance intention (Zhou, 2010). IT adoption studies have consistently found that perceived usefulness is the most important factor in determining users' adoption intentions and usage (Venkatesh and Davis, 2000). Finally, the level of confirmation resulting from the usage experiences is hypothesized to positively affect perceived usefulness and satisfaction.

Confirmation

Just as the cognitive beliefs in IS acceptance contexts (i.e., ease of use and perceived usefulness) are related (Davis et al. 1989), those in IS continuance contexts (i.e., confirmation and perceived usefulness) may also be related to each other (Bhattacherjee, 2001). Hirschman and Holbrook (1982) describe consumers as either problem solvers or seekers of fun and enjoyment and thus refer to utilitarian vs. hedonic values. Utilitarian value is defined as the value that a customer receives based on a task-related and rational consumption behavior (Babin et al., 1994). Hedonic value is defined as the value that a customer receives based on the subject experience of fun and playfulness (Hirschman and Holbrook, 1982; Babin et al., 1994). A user's confirmation implies that he or she achieves expected benefits through the usage experiences with the target IT, and it affects the user's satisfaction level positively (Hong, Thong, and Tam, 2006). Therefore, we assert the following hypotheses:

> *H1. Confirmation has a positive influence on perceived usefulness in Facebook check-in services.*
> *H2. Confirmation has a positive influence on perceived playfulness in Facebook check-in services.*
> *H3. Confirmation has a positive influence on satisfaction in Facebook check-in services.*

Perceived usefulness

Perceived usefulness is defined as "the degree to which a person believes that using a particular system would enhance his or her job performance" [Davis, (1989), p.320]. Although the usefulness-intention association was originally derived in an acceptance context, it also holds true in continuance contexts, because human tendencies to subconsciously pursue instrumental behaviors or strive for rewards are independent of the timing or stage of such behaviors (Bhattacherjee, 2001). It is plausible that perceived usefulness can also influence subsequent continuance decisions (Bhattacherjee, 2001). Therefore, we propose the following hypotheses:

> *H4. Perceived usefulness has a positive influence on satisfaction in Facebook check-in services.*
> *H5. Perceived usefulness has a positive influence on continuance intention in Facebook check-in services.*

Perceived playfulness

Previous research on human-computer interaction (Sandelands and Buckner, 1989; Starbuck

and Webster, 1991) has shown that higher degrees of pleasure and involvement during computer interaction lead to concurrent positive effects and satisfaction. Therefore, perceived playfulness is positively associated with positive effects and satisfaction. If a user feels favorably toward an activity, it is intrinsically motivating and he/she is more likely to engage in the activity more frequently. Consequently, this leads to the following hypotheses:

H6. Perceived playfulness has a positive influence on satisfaction in Facebook check-in services.

H7. Perceived playfulness has a positive influence on continuance intention in Facebook check-in services.

Social norms

Social norms are defined as a user's perception of whether it is important that others approve or disapprove of that user performing a given behavior (Ajzen and Fishbein, 1980). Several studies of IS domain have confirmed the saliency of social norms in user decision-making processes in an IS adoption and user environment (Kim and Han, 2009a). One previous study also showed the significant influence of social norms on community loyalty behavior (Lin, 2010). Some marketing studies also suggested that social norms relate positively to customer loyalty. Furthermore, according to Lu and Lin's 2007 research, loyalty is the intention to keep on using a service, such as a website. Zhou (2011) also suggested that social norms influence online community users' participation intention. Based on earlier discussions on social norms, the research model proposes a positive relationship between social norms and continuance intention.

Interpersonal influence and External influence

Social norms are comprised of interpersonal influence (e.g., word of mouth) and external influence (e.g., mass media), based on theoretical arguments and empirical findings from the innovation diffusion literature (Bhattacherjee, 2000; Rogers, 1995). Interpersonal influence refers to word-of-mouth influence by friends, colleagues, superiors and other prior adopters known to the potential adopters. External influence was defined to include mass media, advertising, and other marketing-related sources (Pathasarathy and Bhattacherjee, 1998; Rogers, 1983).

Hence, on the basis of this reasoning and research stream, we hypothesize:

H8. Interpersonal influence has a positive influence on social norms in Facebook check-in services.

H9. External influence has a positive influence on social norms in Facebook check-in

services.

H10. *Social norms have a positive influence on continuance intention in Facebook check-in services.*

Satisfaction

Satisfaction is defined as a user's sensational cognition and emotional response to the products or services delivered by the service provider (Chen et al., 2010). Danaher and Rust (1996) also found empirical evidence that a customer who is more satisfied with a service will have higher subsequent usage levels. Studies in marketing have discovered that the major reason for the consumer's decision to repurchase products or patronize services is the consumer's level of satisfaction (Bearden and Teel, 1983; Oliver, 1993; Szymanski and Henard, 2001). As such, the hypothesis of the study is as follows:

H11. *Satisfaction has a positive influence on continuance intention in Facebook check-in services.*

Privacy concern

Privacy concern refers to an individual's subjective views of fairness within the context of information privacy (Campbell, 1997). When the level of privacy concern exceeds individual tolerance levels, consumers often manage to reduce the negative effect of risk by methods, such as obtaining additional information (Mitchell, 1999), switching to substitutes with low levels of risk (Yuksel and Yuksel, 2007), or careful evaluations of alternatives and product trials (Cho and Lee, 2006; Dowling and Staelin, 1994). Generally, these discussions imply that the predictive strength of satisfaction on continuance intention decreases when the level of privacy concern increases. Privacy concerns may moderate the link between satisfaction and continuance intention.

Hence, the hypothesis of the study is as follows:

H12. *Privacy concern has a negative moderating effect on satisfaction to continuance intention relationship on Facebook check-in services.*

Table 1   The definition of variable

Variable	definition	Reference
Perceived Usefulness (PU)	An individual considers that participating in Facebook check-in services will provide	Bhattacherjee, MIS Quarterly (2001)

Variable	definition	Reference
	him or her with certain benefits.	
Confirmation (CON)	The extent to which users' expectation of check-in services is realized during actual use derived from prior usage.	Bhattacherjee, MIS Quarterly (2001)
Perceived Playfulness (PP)	The strength of one's belief that interaction with check-in services fulfills his or her intrinsic motives	Moon and Kim, Information and Management 38 (2001)
Satisfaction (SAT)	Satisfaction is defined as user's sensational cognition and emotional response to the check-in services delivered by Facebook.	Chen et al. Computer and Information Science (2010)
Social Norm (SN)	Social norm as the degree to which the user perceived that others approved of his or her participating in Facebook check-in services.	Fishbein and Ajzen, Psychological Bulletin (1975)
External Influence (EI)	External influence refers to mass media reports, expert opinions, and other non-personal information considered by adopters in making a "rational" acceptance decision for Facebook check-in services.	Herr, Kardes, and Kim, Journal of Consumer Research (1991)
Interpersonal Influence (II)	Interpersonal influence refers to word-of-mouth influence by friends, colleagues, superiors, and other prior adopters known to the potential adopters.	Bhattacherjee, System And Human (2000)

Variable	definition	Reference
Privacy Concern (PC)	Privacy concern refers to an individual's subjective views of fairness within the context of information privacy.	Campbell, Journal of Direct Marketing (1997)
Continuance Intention (CI)	An individual's intention to continue using a Facebook check-in service.	Bhattacherjee, MIS Quarterly (2001)

MEASURES

The research model proposed consists of nine aspects, namely: perceived usefulness, perceived playfulness, confirmation, satisfaction, continuance intention, privacy concern, interpersonal influence, external influence, and social norms. We employ established measures from the existing literature to empirically test the hypotheses. All constructs were measured using multi-item perceptual scales and were carried out by a five-point Likert scale, ranging from strongly disagree (1) to strongly agree (5).

DATA COLLECTION

For data collection, we developed a self-administered online survey. Measurement scales were taken from existing scales, with modified wordings to adapt the items to our topic area. In the course of a pretest phase, the questionnaire was reviewed by a small group of IS faculty and doctoral students, and the scales were modified after taking into account their suggestions. The questionnaire was then tested on a sample of the check-in services users. This resulted in some further modifications to the questions. The purpose of these pretests was to confirm that relevant aspects were included and to enhance the clarity and readability of the questionnaire. The final questionnaire of 30 items measuring 11 latent variables is presented in Appendix A.

We conducted an online survey to investigate the role of psychological factors with respect to the intention to use check-in services. We posted an invitation message with the URL to the online questionnaire on a number of Facebook group pages related to check-in experiences.

DATA ANALYSIS AND RESULTS

The Partial Least Squares (PLS) method was used to perform statistical analysis, since the PLS technique provides a better explanation for complex relationships (Fornell and Larcker, 1981) and has been widely adopted by IS researchers (Chin, 1998). Moreover, it is suitable

when the focus of the research is on theory development. The analysis followed the two-step analytical approach: We first conducted the measurement model that was composed to establish the validity and reliability of the theoretical constructs. Second, the structural model was used to conduct a path analysis and test our hypotheses. Using this approach, we are able to more confidently assert that the conclusion on structural relationship is drawn from a set of measurement instruments with desirable psychometric properties.

Descriptive statistics

This survey was undertaken from July 2013 to October 2013 to collect data for testing our hypotheses. The respondents were asked to complete the questionnaire based on their experience with check-in services. A total of 222 responses were received in this study. The results show that 56% were female and 44% were male. The majority of our respondents, 42%, were aged between 21 and 25, 30% were aged between 16 and 20, and 81% of our respondents had a university undergraduate degree or above. The majority of respondents, 72%, had used check-in services for an average of 1-3 years.

Measurement model

The structural and measurement models were estimated using a PLS–Graph. PLS was chosen because it places less restriction on variable distribution and enables modeling higher-order constructs. The convergent validity and discriminate validity of the constructs in our model were examined. Convergent validity was tested using three criteria of all constructs: (1) the composite reliability (CR) should be at least 0.70 (Chin, 1998), (2) the average variance extracted (AVE) should be at least 0.50 (Fornell and Larcker, 1981), and (3) all item loadings should be greater than 0.707 (Chin, 1998). Our analysis demonstrated that all items met the recommended cutoff value of 0.5 with relatively small residual variances that exhibited good psychometric properties. To estimate scale reliabilities, Cronbach's alpha and AVE for each construct were computed. As shown in Table 2, Cronbach's alpha ranged from 0.71 to 0.93 and AVEs ranged from 0.46 to 0.87; these figures all exceeded the recommended score of 0.7 and 0.5, respectively, indicating adequate reliability. This validity was assessed by examining the square root of the AVE for each construct, and it was higher than the corresponding inter-construct correlations. Overall, we concluded that the measures were valid. The square root of the AVE of each construct was located on the diagonal of the Table 3 and was in bold. A reasonable degree of discriminate validity was found since each of them was greater than the correlations between it and all other constructs. In the current study, robust evidence of convergent validity and discriminate validity was found with these data.

Table 2   Construct reliability measures

Construct	Mean	Standard deviation	Cronbach's Alpha	Composite Reliability	AVE
CI	3.347091	1.057942247	0.861024	0.915187	0.782533
CON	3.4165	0.796412342	0.865743	0.917812	0.788253
EI	3.05942	0.89912037	0.935485	0.958745	0.885677
II	3.289533	0.808851939	0.932727	0.957129	0.881564
PC	4.041704	0.812261529	0.856888	0.901744	0.69701
PP	3.761956	0.841334615	0.933898	0.952766	0.834519
PU	3.911995	0.91470065	0.716246	0.836444	0.630416
SAT	3.467297	0.78180672	0.891797	0.925088	0.755605
SAT * PC	-0.029808		0.938231	0.931647	0.461589
SN	3.131567	0.917967985	0.925673	0.952822	0.870685

Table 3   Inter-construct correlations and square roots of AVE of low-order constructs.

	CI	CON	ES	II	PC	PP	PU	SAT	SAT * PC	SN
CI	0.8846									
CON	0.6183	0.8878								
EI	0.4741	0.4194	0.9411							
II	0.5410	0.5552	0.4454	0.9389						
PC	-0.1046	-0.0821	0.0079	-0.0036	0.8349					
PP	0.6781	0.7144	0.4037	0.5618	-0.0791	0.9135				
PU	0.2986	0.4317	0.2795	0.3429	0.2862	0.4110	0.7940			
SAT	0.7111	0.8299	0.4680	0.5481	-0.0733	0.7270	0.4010	0.8693		
SAT * PC	0.2051	0.2059	0.2260	0.1467	-0.0273	0.1989	0.1729	0.2440	0.6794	
SN	0.6275	0.5065	0.5271	0.6169	0.0333	0.4754	0.2973	0.5568	0.1851	0.9331

Structural model

The PLS analysis yielded path coefficients for the structural model. The structural model analysis was assessed based on the test of the hypothesized effects in our research model. Figure 2 shows the results of the hypothesized structural model test. Our research model had an overall explanatory power of R^2 = 63%, 72%, 46%, 51%, 18%, for continuance intention, satisfaction, social norms, perceived usefulness, and perceived playfulness, respectively. The

robust results revealed that usage of check-in services can be satisfactorily predicted by extended ECM.

The result lent support to most of our hypotheses. A surprising result was that the direct paths between perceived usefulness to continuance intention and satisfaction were insignificant, and thus hypothesis H5 and H4 were rejected. The effects of perceived playfulness were positively related to satisfaction and continuance intention evidenced by standardized path coefficients of 0.27, 0.30. Hypotheses H6 and H7 were consequently supported. The effect of confirmation was positively related to satisfaction, perceived playfulness, perceived usefulness with standardized paths coefficient of 0.629, 0.714, 0.432. Hypotheses H3, H2, H1 were thus supported. The effects of interpersonal influence and external influence were positively related to social norms with standardized path coefficients of 0.477, 0.315. As a result, hypotheses H8 and H9 were supported. Social norms and satisfaction had a direct positive relationship with continuance intention, with standardized path coefficients of 0.314 and 0.325, respectively. This provided support for hypotheses H10 and H11. Contrary to expectation, H12 was rejected with an insignificant moderate effect of the interaction between satisfaction and continuance intention.
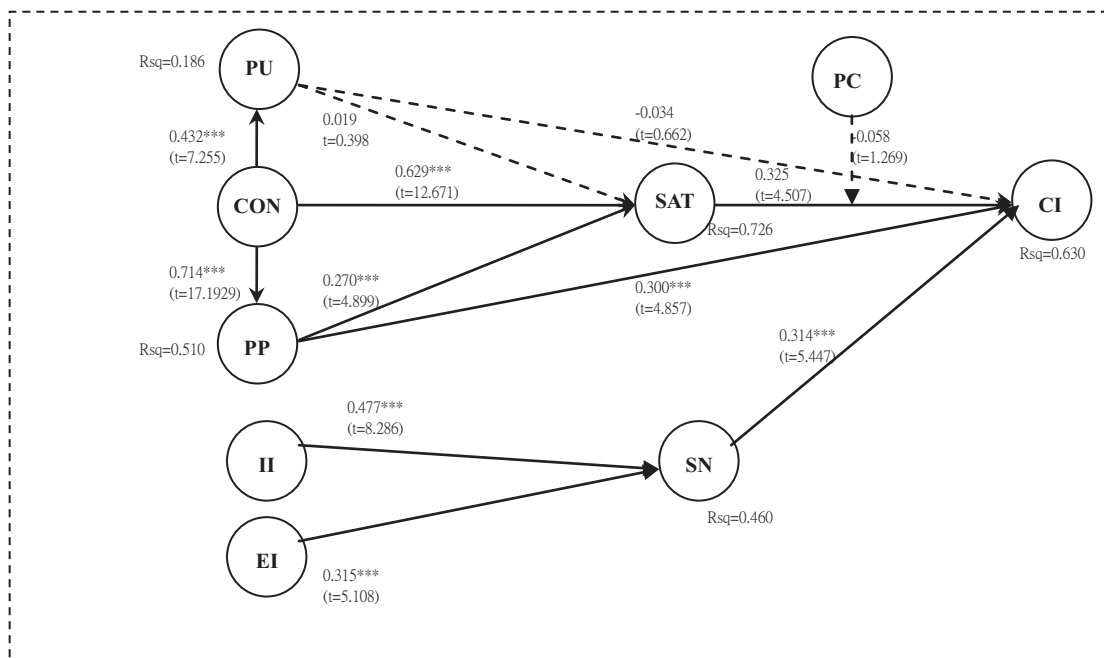
Figure 2   Analysis of results

DISCUSSION AND CONCLUSIONS

The results of this study provide support for the research model and for the hypotheses

regarding the directional linkage among the model's variables. A surprising result was that the direct path between perceived usefulness to continuance intention and satisfaction was insignificant. Merely increasing perceived usefulness may not lead to user's satisfaction and continuance intention in check-in services. It is explainable, the task environment in previous research focused on either use of information system for decision making or use of system in online distance learning or online services. Many check-in users may seek satisfaction from various usage contexts rather than from a performance-oriented context. Making check-in services more playful or enjoyable could contribute more to their satisfaction and enhance their continuance intention as well. However, we found that perceived playfulness had a significant influence on satisfaction and continuance intention, demonstrating that users are more likely to be hedonic orientated than utilitarian orientated when they use check-in services. The results also show that an check-in users' continuance intention is not only affected by the constructs considered in ECM but also by other factors such as social norm with standardized path coefficients of 0.314.

The satisfaction-intention link has previously been validated in consumer behavior research over a wide range of product and service contexts (Bhattacherjee, 2001a, 2001b). Privacy concerns do not seem to influence the direct path between satisfaction and continuance intention. As such, provided a user is satisfied with the check-in services, they will have continuance intention. In addition, the results revealed that users' satisfaction was influenced by confirmation and perceived playfulness but perceived usefulness. When using check-in services, the more enjoyment a user experiences, the more satisfied he/she becomes. Consequently, both interpersonal influence and external influence were found to be significant factors for social norms that accounted for 46% of its variance.

Implications

Implications for academics

In terms of theory building, this study attempts to develop a new theory by adding a number of new variables into an integration of two schools of the derivation of expectation confirmation model, the perceived playfulness, as well as social norms. The proposed model makes an important contribution that accounts for 63% of the variance to the emerging literature on social network field. Our study also provides insight into factors contributing to continuance intention to check-in services, whilst demonstrating that satisfaction, social norm and perceived playfulness were key factors in forming a customer's continuance intention. As pointed out in studies in previous expectation confirmation model, which cover IT as well as IS fields, perceived usefulness plays a strong influence on satisfaction and continuance intention. However, this relationship is not significant in our study (β=0.019, -0.034,

respectively). Perceived playfulness has a significant influence on satisfaction and continuance intention. Check-in users seem to use such services primarily for fun or pleasure rather than for work. Interpersonal influence and external influence are critical antecedents to social norms, and together they account for 46% of the variance. More importantly, social norms are largely explained by interpersonal influence, which is suggested to be a more critical factor for enhancing the level of social norm than external influence. In contrast to previous research, privacy concerns do not hamper the link between satisfaction and continuance. The empirical evidence does not support the moderator role of privacy concerns between satisfaction and continuance intention. Satisfied consumers tend to keep continuance intention even with privacy concerns. The results confirm that the integrated model provides a more complementary understanding of user's continuance decision making than theories considered individually.

Implications for practitioners

Users' continuance intention was significantly influenced by perceived playfulness, social norms, and satisfaction, as anticipated by our hypotheses. In particular, the result shows that satisfaction and social norm are the strong predictors of users' continuance intention. Users' satisfaction is the first priority that must be delivered. Perceived playfulness has a significant influence on satisfaction and continuance intention. Therefore, managers should strive to motivate users' intrinsic motivations, such as enjoyment, fun, curiosity, exploratory behaviors, and flow experience (Choi and Kim, 2000; Hsu and Lu, 2003). Managers have focused on increasing user's fun or pleasure experience, which will in turn lead to users' satisfaction and favorable behavioral intentions. Social norms play a significant role in forming continued usage intention toward check-in services. The effect of interpersonal influence is currently more important than external influence due to network externality effect. The provider should launch the program to increase network externality effect and also should build solid relationships with opinion leaders, who have a normative power to affect other users' to join (Hsu and Lu, 2004). Even though privacy concerns do not hamper the link between satisfaction and continuance intention, as previous papers erroneously suggested, providers still need to monitor such matters.

LIMITATIONS AND SUGGESTIONS

As with any research, care should be taken when generalizing the results of this study. First, the survey was conducted using web-based forms and employed a nonrandom convenience sampling. However, gathering a larger sample using an alternate survey modality and random sampling methods would be costly. The online survey method was appropriate for collecting data from participants with check-in experience and who were free of geographical

constraints. Future studies are suggested to adopt systematical sampling from more diverse samples. Second, our study has only considered the privacy concerns as moderator of satisfaction and continuance intention. Other moderators, such as customer age, gender, and characteristics, must be incorporated in future studies. Third, future studies should include various beliefs that are thought to be relevant to the IT in the literature and examine their impacts on satisfaction, which is expected to facilitate a better understanding of the structure of user satisfaction.

APPENDIX A: THE SURVEY ITEMS

Perceived Usefulness (Bhattacherjee, 2001)

   1. Using Facebook check-in services helps me to realize more easily my current location.

   2. Using Facebook check-in services makes it easier for me to find a friend nearby.

   3. Using Facebook check-in services makes it easier for me to find some shops nearby.

Confirmation (Bhattacherjee, 2001)

  1. My experience with using Facebook check-in services was better than I expected.

  2. The service level provided by Facebook check-in services was better than I expected.

  3. Overall, most of my expectations from using Facebook check-in services were confirmed.

Satisfaction (Chen et al., 2010)

  1. I am satisfied with the value-added services provided by Facebook check-in   services.

  2. I am satisfied with my decision to use Facebook check-in services.

  3. My experience with using Facebook check-in services was very satisfactory.

  4. I think I did the right thing by deciding to use Facebook check-in services.

Continuance Intention (Bhattacherjee, 2001)

  1. I intend to continue using Facebook check-in services in the future.

  2. I will always try to use Facebook check-in services in my daily life.

  3. I will keep using Facebook check-in services as regularly as I do now.

Privacy Concern (Campbell, 1997)

  1. I am concerned that the service provider is collecting too much information about me.

  2. I am concerned that the service provider may not take measures to prevent unauthorized access to my personal information.

  3. I am concerned that the service provider may keep my personal information in a

non-accurate manner in their database.

4. I am concerned that the service provider may share my personal information with other companies without notifying me or getting my authorization.

Perceived Playfulness (Moon and Kim, 2001)

1. Using Facebook check-in services is enjoyable.

2. I have fun using Facebook check-in services.

3. Using Facebook check-in services makes me feel good.

4. I find using Facebook check-in services interesting.

Social Norms (Fishbein and Ajzen, 1975).

1. People who are important to me want me to use Facebook check-in services.

2. People who influence my behavior think I should use Facebook check-in services.

3. People whose opinions I value prefer me to use Facebook check-in services.

Interpersonal Influence (Bhattacherjee, 2000).

1. My family members think that I should use Facebook check-in services.

2. My friends think that I should use Facebook check-in services.

3. My colleagues think that I should use Facebook check-in services.

External Influence (Herr, Kardes, and Kim, 1991).

1. Information from mass media suggests that I should use Facebook check-in services.

2. Information that I learn from mass media encourages me to use Facebook check-in services.

3. Based on what I have heard or seen on mass media, I am encouraged to use Facebook check-in services.

REFERENCE

1. Ajzen, I. and Fishbein, M. (1980) *Understanding attitudes and predicting social behavior,* Englewood Cliffs, Prentice-Hall, NJ.

2. Babin, B.J., Darden, W.R. and Griffin, M. (1994) 'Measuring hedonic and utilitarian shopping value', *Journal of Consumer Research*, Vol. 20 No. 4, pp. 644 - 656.

3. Bearden, W.O. and Teel, J. E. (1983) 'Selected determinants of consumer satisfaction and complaint reports', *Journal of Marketing Research*, Vol. 20 No. 1, pp. 21-28.

4. Bhattacherjee, A. (2001) 'An empirical analysis of the antecedents of electronic commerce service continuance', *Decision Support Systems*, Vol. 32 No. 2, pp. 201-214.

5. Bhattacherjee, A. (2000) 'Acceptance of e-commerce services: The case of electronic brokerages', *IEEE Transactions on Systems, Man, and Cybernetics*, Vol. 30 No. 4, pp. 411-420.

6. Bhattacherjee, A. (2001) 'Understanding information systems continuance: An expectation-confirmation model', *MIS Quarterly*, Vol. 25 No. 3, pp. 351-370.

7. Campell, A.J. (1997) 'Relationship marketing in consumer markets: A comparison of managerial and consumer attitudes about information privacy', *Journal of Direct Marketing*, Vol. 11 No. 3, pp. 44-57.

8. Chang, S.E., Hsieh, Y.J., Lee, T.-R., Liao, C.K. and Wang, S.T. (2007) 'A user study on the adoption of location based services', *Advances in Web and Network Technologies, and Information Management*, Chang, K.C. et al. (eds.), Springer, pp. 276-286.

9. Chen, Y.Y. and Huang, H.L. (2010) 'Confirmation of expectations and satisfaction with the Internet shopping: The role of Internet self-efficacy', *Computer and Information Science*, Vol. 3 No. 3, pp. 14-22.

10. Chin, W.W. (1998) 'The partial least squares approach for structural equation modeling'. *Modern Methods for Business Research*, George A. Marcoulides, Lawrence Erlbaum Associates, N.J.

11. Cho, L. and Lee, J. (2006) 'An integrated model of risk and risk-reducing strategies', *Journal of Business Research*, Vol. 59 No. 1, pp. 112-120.

12. Choi, D., Kim, H. and Kim, J. (2000) 'A Cognitive and Emotional Strategy for Computer Game Design', *Journal of MIS Research*, Vol. 10, pp. 165-187.

13. Danaher, P.J. and Rust, R.T. (1996) 'Indirect financial benefits from service quality', *Quality Management Journal*, Vol. 3 No. 2, pp. 63–75.

14. Davis, F.D. (1989) 'Perceived usefulness, perceived ease of use, and user acceptance of information technology', *MIS Quarterly*, Vol. 13 No. 3, pp. 319-340.

15. Dowling, G.R. and Staelin, R., (1994) 'A model of perceived risk and intended risk-handling activity', *Journal of Consumer Research*, Vol. 21 No. 1, pp. 119-134.

16. Festinger, L.A. (1957) *A Theory of Cognitive Dissonance*, Evanston, Row and Peterson, Stanford University Press, Stanford, California.

17. Fornell, C. and Larcker D.F. (1981) 'Evaluating structural equation models with unobservable variables and measurement error', *Journal of Marketing Research*, Vol. 18 No. 3, pp. 39-50.

18. Frank, P.M., Kardes, R. and Kim, J. (1991) 'Effects of word-of-mouth and product-attribute information on persuasion: An accessibility-diagonosticity perspective', *Journal of Consumer Research*, Vol. 17 No. 4, pp. 454-462.

19. Hirschman, E.C. and Holbrook, M.B. (1982) 'Hedonic consumption: Emerging concepts, methods and propositions', *Journal of Marketing*, Vol. 46 No. 3, pp. 92-101.

20. Hong, S.-J., Thong, J.Y.L. and Tam, K.Y. (2006) 'Understanding continued information technology usage behavior: A comparison of three models in the context of mobile internet', *Decision Support Systems*, Vol. 42 No. 3, pp. 1819-1834.

21. Hsu, C.L. and Lu, H.P. (2007) 'Consumer behavior in online game communities: A motivational factor perspective', *Computers in Human Behavior*, Vol. 23, pp. 1642-1659.

22. Hsu, C.L. and Lu, H.P. (2003) 'Why do people play on-line games? An extended TAM with social influences and flow experience', *Information and Management*, Vol. 41, pp. 853–868.

23. Hsu, M.H. and Chiu, C.H. (2004) 'Predicting electronic service continuance with a decomposed theory of planned behaviour', *Behaviour & Information Technology,* Vol. 23 No. 5, pp. 359–373.

24. Kim, B., Choi, M. and Han, I. (2009) 'User behaviors toward mobile data services: The role of perceived fee and prior experience', *Expert Systems with Application*, Vol. 36 No. 4, pp. 8528-8536.

25. Kim, B. and Han, I. (2009) 'The role of trust belief in community-driven knowledge and its antecedents', *Journal of the American Society for Information Science and Technology*, Vol. 60 No. 5, pp. 1012-1026.

26. Kim, B. and Han, I. (2009a) 'What drives the adoption of mobile data services? A approach from a value perspective', *Journal of Information Technology*, Vol. 24 No. 1, pp. 35-45.

27. Limayem, M. and Cheung, C.M.K. (2008) 'Understanding information systems continuance: The case of Internet-based learning technologies', *Information & Management*, Vol. 45 No. 4, pp. 227-232.

28. Limayem, M., Hirt, S.G. and Cheung, C.M.K. (2007) 'How habit limits the predictive power of intention: The case of information systems continuance', *MIS Quarterly*, Vol. 31 No. 4, pp. 705-737.

29. Lin, C.P. (2010) 'Learning virtual community loyalty behavior from a perspective of social cognitive theory', *International Journal of Human-Computer Interaction*, Vol. 26 No. 4, pp. 345-360.

30. Lin, C.S., S. Wu and R.J. Tsai, (2005) 'Integrating perceived playfulness into expectation-confirmation model for web portal context', *Information & Management*, Vol. 42 No. 5, pp. 683-693.

31. May, A., Bayer, S.H. and Ross, T. (2007) 'A survey of 'young social' and 'professional' users of location based services in the UK', *Journal of Location Based Services,* Vol. 1 No. 2, pp. 112-132.

32. Mitchell, V.W. (1999) 'Consumer perceived risk: Conceptualizations and models', *European Journal of Marketing*, Vol. 33 No. 2, pp. 163-195.

33. Moon, J. and Kim, Y. (2001) 'Extending the TAM for a World Wide Web context', *Information & Management*, Vol. 38 No. 4, pp. 217-230.

34. Oliver, R.L. (1993) 'Cognitive, affective, and attribute bases of the satisfaction response', *Journal of Consumer Research*, Vol. 20, pp. 418-430.

35. Parthasarathy, M. and Bhattacherjee, A. (1998) 'Understanding post-adoption behavior in the context of online services', *Information Systems Research*, Vol. 9 No.4, pp. 362-379.

36. Reichheld, F.F. and Schefter, P. (2000) E-loyalty: your secret weapon on the wed, Harvard Business Review, Vol.78 No.4, pp. 105-13.

37. Rogers, E.M. (1995) *Diffusion of Innovations*, 4th ed., Free Press, New York.

38. W.H. and Webster, J. (1991) 'When is play productive?', *Accounting, Management, and Information Technology*, Vol. 1 No. 1, pp. 71–90.

39. Sandelands, L.E. and Buckner, G.C. (1989) 'Of art and work: Aesthetic experience and the psychology of work feelings', Cummings, L.L. and Staw, B.M. (eds.), *Research in Organizational Behavior (II)*, pp. 105-131, Greenwich, JAI Press, CT.

40. Szymanski, D.M. and Henard, D.H. (2001) 'Customer satisfaction: A meta-analysis of the empirical evidence', *Journal of the Academy of Marketing Science*, Vol. 29 No. 1, pp. 16-35.

41. Thompson S. H. Teo, Shirish C. Srivastava, Li Jiang. (2009) 'Trust and Electronic Government Success: An Empirical Study', *Journal of Management Information Systems*, Vol. 25 No. 3, pp 99-132.

42. Thong, J.Y.L., Hong, S.J. and Tam, K.Y. (2006) 'The effects of post-adoption beliefs on the expectation-confirmation model for information technology continuance', *International Journal of Human-Computer Studies*, Vol. 64 No. 9, pp. 799-810.

43. Venkatesh, V. and Davis, F.D. (2000) 'A theoretical extension of the technology acceptance model: Four longitudinal field studies', *Management Science*, Vol. 46 No. 2, pp. 186-204.

44. Yuksel, A. and Yuksel, F. (2007) 'Shopping risk perception: Effects on tourists' emotion, satisfaction and expressed loyalty intentions', *Tourism Management*, Vol. 28 No. 3, pp. 303-313.

45. Zhou, T. (2011) 'Examining the critical success factors of mobile website adoption', *Online Information Review*, Vol. 35 No. 4, pp. 636-652.

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RANKING THE BRANCHES OF INSURANCE COMPANIES BASED ON SERVICE QUALITY LEVEL VIA SERVQUAL SCALE AND ANP MODEL

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ABSTRACT

Service firms play an increasingly important role in global economy. One specific service industry that has internationalized rapidly in recent years is insurance industry. The aim of this study was to evaluate the services quality of insurance co. branches in Islamic republic of Iran (I RR) to measure policyholder views toward current level and expected level of quality via the standard questionnaire "SERVQUAL" in order to rank the insurance branches scientifically. The proposed pattern uses the Analytic Network Process (ANP) as a Multiple Criteria Decision Making (MCDM) tool which allows measurement of the dependency among the service quality dimensions: tangibles, reliability, responsiveness, assurance and empathy. Dependency among SERVQUAL dimensions is observed to affect the priorities and ranking strategies. Dealing with the five dimensions of SERVQUAL as output, the proposed approach utilizes ANP method which is suggested to be a good tool for ranking the branches of insurance co. in a scientific manner. The results showed significant difference between policyholder expectations and current level of quality of services in reliability dimension of quality. The other criteria according to weighted matrix were ranked in this order, Responsiveness, Assurance, Tangibility and Empathy in service quality and alternatives were ranked in this order, VAHDAT, SADGHIYEH, 7TIR and the last one was AZADI branch which showed that there is a significant difference between the traditional method assessment which is based only on financial criterion and the scientific and the proposed assessment method which is an engineering model and all of this model is our own work.

Keywords: MCDM, ANP, Selection, Insurance Industry.

INTRODUCTION

Rational decision-making is a talent we must encourage if we want to be more effective in implementing our ideas in the real world with its risks and resistance to change. There are two types of decisions the first one is to determine what we prefer the most, known as normative decision-making in these circumstances it is easy to see why we do not wish anything to happen that can undermine the best choice we make. The second one is descriptive decision-making which is how to make a best choice given all the influences in the world around us that can affect the optimality of any choice we make thus if we choose this type as an alternative to the first one we do not want it to be influenced by the other alternative that occur to us later. The first ones are falsifiable statements that attempt to describe the real world as it is and normative ones legislate how things ought to be and can never be proven to be correct and workable, but only disproved with examples of what the recommended failing [1]. In reality how good any choice we make depends on how well we know our alternatives as compared with each other and with others outside the collection being compared so we can rank them as to how good they are. Decision-making involves prioritizing ideas according to the circumstances we face now or might face in the future. A fundamental problem is how to measure intangible criteria and how to interpret them to yield sensible. The ANP is fundamentally a way to measure intangibles factors by using pair wise comparisons with judgments that represent the dominance of one element over another with respect to a property that they share [2].The ANP has found useful application in decision making which involves numerous intangibles. It is a process of laying out a structure of all essential factors that influence the outcome of a decision. Numerical pair wise comparison judgments are then elicited to express peoples understanding of the importance, performance or likely influence of these elements on the final outcome obtained by synthesizing the priorities derived from different sets of pair wise comparisons and sensitivity analysis is performed in the end to determine the stability of the outcomes to wide perturbations in the judgments [3].Undoubtedly all organizations are in search of attaining a desirable quality this issue is of greater importance in serving organizations [4].since service quality is increasingly as a critical determinant of business performance and strategic tool tor gaining competitive advantages ,measuring service quality has been a matter of grave concerns for both practitioners and researchers during the past two decades[5]. Notwithstanding the most popular measure of service quality is SERVQUAL developed by Parasuraman [6]. A number of applications of SERVQUAL has been reported in variety of settings [7]. The original instrument of Servqual comprised of five dimensions with 22 items and analysis of these data can take several forms such as item-by-item analysis, dimension-by-dimension analysis and computation of the single measure of overall service quality [8].services play an increasingly important role in the I.R.I and also in the global economy and have in fact become more important than goods. for instance services produced by insurance industry accounted for .1% of Gross Domestic Product (GDP) in 2011 and it is supposed to be 1.45%in 2015 [9].services differ from goods in several important

ways for instance while goods are tangible and can be stored services are often intangible and must be produced and consumed simultaneously [10]. To the best of our knowledge studies of utilizing of ANP to rank insurance branches based on their service quality are so far lacking. The aim of this paper is to fill this gap by examining the ANP utilization in scientifically ranking the branches of firms operating in financial service industry specifically insurance industry based on their service quality level. Our decision to study insurance industry is motivated by some factors: first the insurance industry has experienced an acceptable volume of domestic direct and indirect investment in recent years in IRI, mainly due to new technological advancements governmental liberalization policies which have created many opportunities for private insurance firms to become active in financial market and more over insurance industry is one of the largest service industry in Iran. The second one is that an insurance policy involves the payment of a premium over long period of time in order to generate a specific type of benefit for the policy holder in the future as a result policy holders are likely to have long-term relationship with their insurance firms and are likely to have a specific interest in the performance of their insurer [11].so together with the lack of international management research on insurance firms and their branches and specially their scientifically ranking method, make the insurance industry and ranking models an interesting service industry to study.

MATERIALS

Servqual:
Different researches have presented various definitions regarding quality of services some of them believe that the quality of the perceived service is the result of the assessment of the clients 'expectations and the perceived services. Service quality is a stable criterion that indicates how the presented services correspond with the clients expectations. Some of them define service quality as the presentation of services in a way much better than what the client expect [12]. Despite general agreement concerning a definition it can be mentioned that the comprehensive and the mostly accepted definition belongs to parasuraman et al [13]. According to this definition service quality is related to satisfaction but not equal to that in a sense which it is attained via the difference between clients' expectations and their perceptions of service attaining. Parasuraman et al. in their studies identified 10 dimensions for the identification of service quality: facilities, reliability, responsibility, communication, credit, security, qualification, politeness, understanding of the client, and availability. Later, they summarized these into five dimensions. SERVQUAL can also be defined as a multiple-item scale composed of five dimensions and 22 items for measuring consumer perceptions of service quality [13, 14]. Table 1 presents the five dimensions of SERVQUAL. The survey instruments for SERVQUAL of include the 22 items for measuring expectations (E) and the corresponding 22 items for measuring perceptions (P). Five or seven point liker's scale from "Strongly Disagree (1) to Strongly Agree (7)" can be used for

measurement. For each item, a difference score gap obtained as the difference between the ratings on perception (P) and expectation (E); that is, $G = P - E$.[15].

Table1. Dimensions of Servqual, [15]

Dimensions	Definition	Number of item
Tangible	Physical facilities, equipment, appearance of personnel and organization accommodations	4
Reliability	Ability to perform the promised service dependably and accurately and precisely	5
Responsiveness	Willingness to help customers and provide prompt service and disposition to quickly serve the clients	4
Assurance/ Guarantee	Knowledge and courtesy of employees and their ability to inspire trustand confidence	4
Empathy/ Sympathy	Caring, individualized attention the firm provides to its customers / personal attention to each client	5

Analytic network process:

The ANP is a mathematical theory that can deal with all kinds of dependence systematically. The ANP has been successfully applied in many fields [16]. ANP has a systematic approach to set priorities and trade-offs among goals and criteria, and also can measure all tangible and intangible criteria in a model.

Many decision problems cannot be structured hierarchically because they involve the interaction and dependence of higher-level elements in a hierarchy on lower-level elements. Not only does the importance of the criteria determine the importance of the alternatives as in a hierarchy, but also the importance of the alternatives themselves determines the importance of the criteria. And also feedback enables us to factor the future into the present to determine what we have to do to attain a desired future. The Analytic Network Process is a generalization of the Analytic Hierarchy Process (AHP). The basic structures are networks. Priorities are established in the same way they are in the AHP using pair wise comparisons and judgments. The feedback structure does not have the top-to-bottom form of a hierarchy but it looks more like a network, with cycles connecting its components of elements, and we can no longer call them levels, with loops that connect a component to it [17]. Traditional MCDM methods are based on the additive concept along with the independence assumption, but individual criterion is not always completely independent. For solving the interactions among elements, the analytic network process (ANP) as a relatively new MCDM method which was proposed by Saaty [18].

This study involves numbers of pair wise comparisons for deriving the priorities of branches of insurance companies' evaluation and ranking. Synthesizing experts' opinions is in compliance

with the geometric mean method Buckley [19]. The valuation scales used in the study are those recommended by Saaty [3,18], where 1 is equal importance, 3 moderate importance, 5 is strong importance, 7 is very strong or demonstrated importance, and 9 is extreme importance. Even numbered values will fall in between importance levels. Reciprocal values (e.g. 1/3, 1/5, etc.) mean less importance, even less importance, etc. Saaty [3] proved that for consistent reciprocal matrix, the λ max value is equal to the number of comparisons, or λ max = n. A measure of consistency was given, called Consistency Index as deviation or degree of consistency using the following formula. If the value of I.I. Ratio [I.I. =(λ max − n)/(n−1)] is smaller or equal to 10%, the inconsistency is acceptable. If the I.I. ratio is greater than 10%, the subjective judgment needs to be revised. N in the formula denotes the number of elements that have been compared. When λ max = 0, the complete consistency exists within judgment procedures and then λ max = n. The consistency ratio (I.R.) of I.I. to the mean random consistency index (I.I.R) is expressed as I.R. (I.R. = I.I./ I.I.R) less than 0.1. The outcome of the process above is able to compose an un-weighted super matrix. Its columns contain the priorities derived from the pair wise comparisons of the elements. In an un-weighted super matrix, its columns may not be column stochastic. To obtain a stochastic matrix, i.e., each column sums to one, the blocks of the un-weighted super matrix should be multiplied by the corresponding cluster priority. To derive the overall priorities of elements, this method involves multiplying sub-matrices numerous times in turn, until the columns stabilize and become identical in each block of sub-matrices.

The weighted super matrix can then be raised to limiting powers to calculate the overall priority weights. The ANP employs the limiting process method lim $k\to\infty$ Wk of the powers of the super matrix [18; 20; 21]. For synthesizing overall priorities for the alternatives, the un-weighted super matrix requires adjusting in order to keep it column stochastic [22].

RESEARCH METHOD

Applying ANP to matrix operations in order to determine the overall priorities of the criteria identified with SERVQUAL analysis and to rank the insurance branches (alternatives) was our main goal for which the steps of our proposed engineering model were as:

- A- Identification of insurance branches by cluster sampling.
- B- Designing and distributing of SERVQUAL questionnaire among the elements of sample.
- C- Determination the criteria weights.
- D- Determination of importance degree of alternatives and criteria by ANP.
- E- Calculations of ANP and the super matrix.
- F- Determination of the limit super matrix.
- G- Selecting and ranking the best alternative based on service quality integrated by ANP.

The research method is descriptive-survey which has been selected on the basis of the nature of this research. The population of this research includes all the policy holders who were living in zone 1(this zone contains the policy holders who are in Tehran and will be described later in this paper) from 2012 to 2013.376 policy holders were sampled based on volume assessment sample formula. The instrument was the standard SERVQUAL questionnaire which was designed on the basis of lickers 'seven scales and distributed among the participants [15]. To analyze the data, SPSS software was used at the two levels of descriptive and analytical statistics. At the level of descriptive statistics, frequency, percentage, mean and standard deviation were used and at the level of analytical statistics dependent t-test, were used to investigate the policy holders' opinions. Sample volume was calculated according to the following formula [23].

$$(1) \quad n = \frac{z^2 \sigma^2}{d^2}$$

Where D=desired precision (or maximum error) andσ^2 =assumed population variance,$Z_{\alpha/2}$ =critical normal deviate for specified reliability1-α

To calculate the variance and reliability 40 questionnaires were distributed among policy holders the variance was equal to .5789 and previous studies indicate that desired precision of d=.077,with reliability probability of 1-α=.95 and from critical normal deviate values table we know that $Z_{/520}$=1/69 thus the required sample size is 376.(rounded) and the reliability was estimated via Cronbach's alpha (perceptions 92% and expectations90%) by SPSS software.

Our ANP model for SERVQUAL is shown in figure 1 which contains 4 alternatives (four branches of DANA insurance co.) and five criteria (SERVQUAL factors) and the goal of the model was to find the superior branch among the others according to policy holders' opinions.
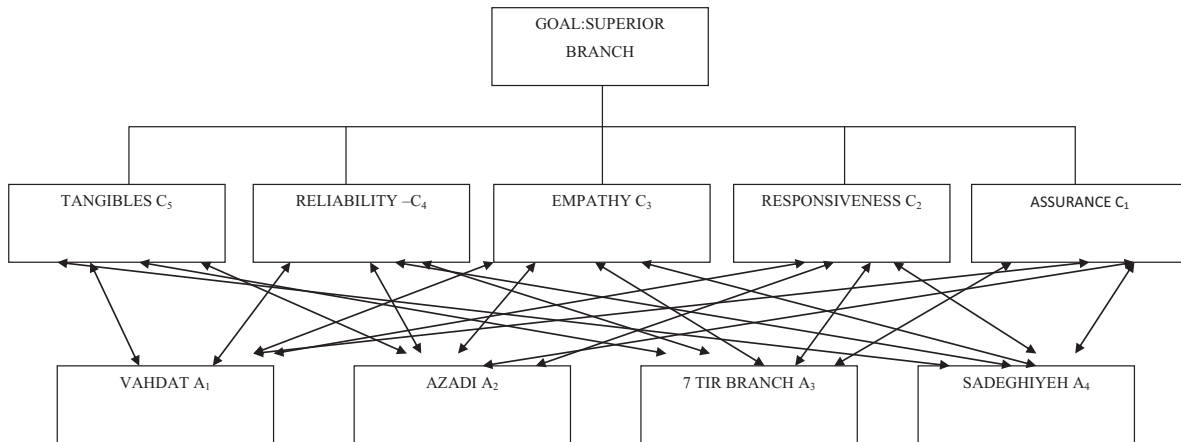
Figure 1 the clusters and nodes of the model to select the best alternative based on SERVQUAL

The ANP is composed of four major steps:

Step 1: Model construction and problem structuring: The problem should be stated clearly and be decomposed into a rational system, like a network. This network structure can be obtained by decision-makers through brainstorming or other appropriate methods.

Step 2: Pair wise comparison matrices and priority vectors: Similar to the comparisons performed in AHP, pairs of decision elements at each cluster are compared with respect to their importance towards their control criteria. The clusters themselves are also compared with respect to their contribution to the objective. Decision-makers are asked to respond to a series of pair wise comparisons of two elements or two clusters to be evaluated in terms of their contribution to their particular upper level criteria. In addition, interdependencies among elements of a cluster must also be examined pair wise; the influence of each element on other elements can be represented by an eigenvector. The relative importance values are determined with Saaty's 1–9 scale (Table 2), where a score of 1 represents equal importance between the two elements and a score of 9 indicates the extreme importance of one element (row cluster in the matrix) compared to the other one (column cluster in the matrix) [24].A reciprocal value is assigned to the inverse comparison, that is, $a_{ij} \frac{1}{4} 1 = a_{ji}$, where a_{ij} (a_{ji}) denotes the importance of the i_{th} (j_{th}) element. Like with AHP, pair wise comparison in ANP is performed in the frame work of a matrix, and a local priority vector can be derived as an estimate of the relative importance associated with the elements (or clusters) being compared by solving the equation 2:

$$(2)\ A \times W = \lambda_{MAX} \cdot W$$

Where A is the matrix of pair-wise comparison, w is the eigenvector, and λ_{max} is the largest

eigenvector value of Saaty[3] proposes several algorithms to approximate w. In this paper, super decision is used to compute the eigenvectors from the pair-wise comparison matrices and to determine the consistency ratios.

Table 2-Saaty's 1–9 scale for AHP preference [18]

Intensity of importance	Definition
1	Equal importance
3	Moderate importance
5	Strong importance
7	Very strong importance
9	Absolute importance
2,4,6,8	Intermediate importance
Reciprocal of above non-zero numbers	If activity i has one of the above non-zero numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i

Each matrix should be normalized by the following formulas:

a-in the case of positive criteria:

$$(3) \quad a_{ij} = \frac{a_{ij}}{\sum\limits_{i=1}^{m} a_{ij}}$$

b-in the case of negative criteria:

$$(4) \quad a_{ij} = \frac{\frac{1}{a_{ij}}}{\sum\limits_{i=1}^{m} \frac{1}{a_{ij}}}$$

The consistency index we chose is as below [17]:

$$(5) \, I.I. = \frac{\lambda_{MAX} - n}{n-1}$$

And the rate of inconsistency is calculated according to the following formula:

$$(6) \, I.R. = \frac{I.I}{I.I.R}$$

Where *I.I.R random index* is chosen from random index table, is shown in table 3.

Table3. Random index table [17]

Order	1	2	3	4	5	6	7	8	9
I.I.R	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45

Step 3: Super matrix formation: The super matrix concept is similar to the Markov chain process [18]. To obtain global priorities in a system with interdependent influences, the local priority vectors are entered in the appropriate columns of a matrix. As a result, a super matrix is actually a partitioned matrix, where each matrix segment represents a relationship between two clusters in a system. The local priority vectors obtained in Step 2 are grouped and placed in the appropriate positions in a super matrix based on the flow of influence from one cluster to another, or from a cluster to itself, as in the loop. A standard form for a super matrix is as shown below.

$$
w_{ij} = \begin{bmatrix}
w_{11} & w_{1k}..... & w_{1n} \\
w_{k2} & w_{kk}..... & w_{kn} \\
& & \\
w_{n1} & w_{nk}..... & w_{nn}
\end{bmatrix}
$$

Note that any zero value in the super matrix can be replaced by a matrix if there is an interrelationship of the elements within a cluster or between two clusters. Since there usually is interdependence among clusters in a network, the columns of a super matrix may sum to more than one. However, the super matrix must be modified so that each column of the matrix sums to unity. An approach recommended by Saaty [18] involves determining the relative importance of the clusters in the super matrix, using the column cluster as the controlling cluster. That is, row clusters with non-zero entries in a given column cluster are compared according to their impact on the cluster of that column cluster. An eigenvector is obtained from the pair wise comparison matrix of the row clusters with respect to the column cluster, which in turn yields an eigenvector for each column cluster. The first entry of the respective eigenvector for each column cluster, is multiplied by all the elements in the first cluster of that column, the second by all the elements in the second cluster of that column and so on. In this way, the cluster in each column of the super matrix is weighted, and the result, known as the weighted super matrix, is stochastic. Raising a matrix to exponential powers gives the long-term relative influences of the elements on each other. To achieve convergence on the importance weights, the weighted super matrix is raised to the power of 2k + 1,(W=Lim W^{2k+1})where k is an arbitrarily large number; the new matrix is called the limit supermatrix[18]. The limit supermatrix has the same form as the weighted supermatrix, but all the columns of the limit supermatrix are the same. The final priorities of all elements in the matrix can be obtained by normalizing each cluster of this supermatrix. Additionally, the final priorities can be calculated using matrix operations, especially where the

number of elements in the model is relatively few. Matrix operations are used in order to easily convey the steps of the methodology and how the dependencies are worked out.

Step 4: Selection of the best alternatives: If the supermatrix formed in Step 3 covers the whole network, the priority weights of the alternatives can be found in the column of alternatives in the normalized supermatrix. On the other hand, if a supermatrix only comprises clusters that are interrelated; additional calculations must be made to obtain the overall priorities of the alternatives. The alternative with the largest overall priority should be selected, as it is the best alternative as determined by the calculations made using matrix operations.

Case study
This section presents an illustration of the proposed approach summarized in the previous sections. In the following case study, SERVQUAL method utilizing the ANP analysis is performed on DANA Insurance CO. Which is one of the largest Iranian insurance co. and is centralized administration in Tehran with more than 40 branches throughout the country which are divided in to 8 zones and this co. makes use of traditional ranking system. It has tree type of branches, superior branch, level 1 branch and level 2 branch which are annually assessed by their annual portfolio (annual sale level) then ranked by this criterion. The higher the portfolio, the higher ranking level will be allocated to. In this paper we want to test if there is a difference between the traditionally assessment and the proposed engineering model. The following example is presented for the purpose of illustration of the proposed approach. The data for the five dimensions of SERVQUAL for service quality units were generated for both perceptions and expectations in four branches as our alternatives. Then, ANP was conducted with the data set of SERVQUAL. Table4 presents the generated data and results of SERVQUAL.

The statistical analysis revealed that the mean for expectations was 22.056 and for perceptions was 19.203 and t result was 23.22 at p .001 so the data analysis of the policy holders' expectations and perceptions in all dimensions of service quality showed that they were significant at $p < 0.05$, and there was a gap between their expectations and their perceptions which showed that the insurer could not satisfy the policy holders with their expectations.

Table4. Generated data of SERVQUAL

criteria / alternatives	c_1	c_2	c_3	c_4	c_5	Total
A_1	0.5025	0.7475	0.7046	0.9488	0.5268	3.4312
A_2	0.541	1.1375	0.6474	0.6928	0.60825	3.627
A_3	0.7075	0.7225	0.5666	0.832	0.725	3.554
A_4	0.8875	1.1925	0.284	0.926	0.4	3.69

ANP calculations:

This section consists of 2 parts. a: comparison of criteria with all alternatives and b; comparison of alternatives with all criteria. The results of these comparisons are shown in table 5 as super matrix and table 6 as the limit super matrix.

6-a-criteria comparison with alternatives

6-a-1- assurance criterion (c_1) comparison with alternatives:

$$w = \begin{bmatrix} .312 \\ .289 \\ .223 \\ .176 \end{bmatrix} \rightarrow I.I = \frac{4.0045 - 4}{3} = 0.0015 \rightarrow I.I.R = \frac{0.0015}{0.9} = 0.0017 \langle 0.1$$

6-a-2- responsiveness criterion (c_2) comparison with alternatives:

$$w = \begin{bmatrix} .301 \\ .198 \\ .312 \\ .189 \end{bmatrix} \rightarrow I.I = \frac{4.0015 - 4}{3} = 0.0005 \rightarrow I.I.R = \frac{0.0005}{0.9} = 0.0055 \langle 0.1$$

6-a-3- empathy criterion (c_3) comparison with alternatives:

$$w = \begin{bmatrix} .172 \\ .187 \\ .214 \\ .427 \end{bmatrix} \rightarrow I.I = \frac{4.0075 - 4}{3} = 0.0025 \rightarrow I.I.R = \frac{0.0025}{0.9} = 0.0003 \langle 0.1$$

6-a-4- reliability criterion (c_4) comparison with alternatives:

$$w = \begin{bmatrix} .221 \\ .302 \\ .251 \\ .226 \end{bmatrix} \rightarrow I.I = \frac{4.0000 - 4}{3} = 0.0000 \rightarrow I.I.R = \frac{0.0000}{0.9} = 0.0000 \langle 0.1$$

6-a-5- tangibles criterion (c_5) comparison with alternatives:

$$w = \begin{bmatrix} .256 \\ .221 \\ .186 \\ .337 \end{bmatrix} \rightarrow I.I = \frac{4.00125 - 4}{3} = 0.0042 \rightarrow I.I.R = \frac{0.00042}{0.9} = 0.00046 \langle 0.1$$

6-b-alternatives comparison with criteria:
6-b-1-vahdat branch (A_1) comparison with all SERVQUAL criteria:

$$w = \begin{bmatrix} .146 \\ .218 \\ .205 \\ .277 \\ .154 \end{bmatrix} \rightarrow I.I = \frac{5.0004 - 5}{4} = 0.0001 \rightarrow I.I.R = \frac{0.0001}{1.12} = 0.00009 \langle 0.1$$

6-b-2-azadi branch (A_2) comparison with all SERVQUAL criteria:

$$w = \begin{bmatrix} .149 \\ .313 \\ .179 \\ .191 \\ .168 \end{bmatrix} \rightarrow I.I = \frac{5.045 - 5}{4} = 0.1125 \rightarrow I.I.R = \frac{0.1125}{1.12} = 0.01 \langle 0.1$$

6-b-3-7tir branch (A_3) comparison with all SERVQUAL criteria:

$$w = \begin{bmatrix} .199 \\ .203 \\ .159 \\ .234 \\ .204 \end{bmatrix} \rightarrow I.I = \frac{5.0146 - 5}{4} = 0.00365 \rightarrow I.I.R = \frac{0.0365}{1.12} = 0.0033 \langle 0.1$$

6-b-4-sadeghiyeh branch (A_3) comparison with all SERVQUAL criteria:

$$w = \begin{bmatrix} .241 \\ .323 \\ .077 \\ .251 \\ .108 \end{bmatrix} \rightarrow I.I = \frac{5.0008 - 5}{4} = 0.0002 \rightarrow I.I.R = \frac{0.0002}{1.12} = 0.00018 \langle 0.1$$

Table 5. The super matrix:

	C_1	C_2	C_3	C_4	C_5	A_1	A_2	A_3	A_4
C_1	0	0	0	0	0	0.146	0.149	0.199	0.241
C_2	0	0	0	0	0	0.218	0.313	0.203	0.323
C_3	0	0	0	0	0	0.205	0.179	0.159	0.077
C_4	0	0	0	0	0	0.277	0.191	0.234	0.251
C_5	0	0	0	0	0	0.154	0.168	0.204	0.108
A_1	0.312	0.301	0.172	0.221	0.256	0	0	0	0
A_2	0.289	0.198	0.187	0.302	0.221	0	0	0	0
A_3	0.223	0.312	0.214	0.251	0.186	0	0	0	0
A_4	0.176	0.189	0.427	0.226	0.337	0	0	0	0

Table 6. The limit super matrix:

$w^5 =$	C_1	C_2	C_3	C_4	C_5	A_1	A_2	A_3	A_4
C_1	0	0	0	0	0	0.183964317	0.183985235	0.183801168	0.184074242
C_2	0	0	0	0	0	0.222924826	0.222833677	0.222043687	0.222245302
C_3	0	0	0	0	0	0.174698925	0.174663932	0.174518175	0.174540533
C_4	0	0	0	0	0	0.238944804	0.238939172	0.238707585	0.238948024
C_5	0	0	0	0	0	0.177914046	0.177891411	0.177743204	0.177818801
A_1	0.256763133	0.256736739	0.256607967	0.256714	0.2566763	0	0	0	0
A_2	0.241457809	0.241424701	0.241387689	0.241436	0.2414222	0	0	0	0
A_3	0.245708829	0.245688855	0.245625035	0.245676	0.2456764	0	0	0	0
A_4	0.255427991	0.255416433	0.25575823	.0255504	0.2556396	0	0	0	0

RESULTS

The aim of this research was to assess the service quality of the branches of insurance companies by applying SERVQUAL model and combining the results by ANP in order to propose a scientific ranking model. The participants included policy holders who were randomly selected by cluster sampling method and the instrument was the standard SERVQUAL questionnaire with five dimensions (assurance, empathy, tangibles, responsibility and reliance). The reliability of the instrument was measured by Cronbach's alpha(perceptions 0.92 and expectations 0.90). Data analysis was conducted and revealed that there was gap in the policy holders' expectations ($\mu = 22.056$) and perceptions ($\mu = 19.203$) in the all dimensions of SERVQUAL it was significant at p<0.05.Results showed that alternatives ranked in this order1-VAHDAT 2-SADEGHIEH. 3-7TIR 4-AZADIwhere in accordance with traditional assessment ranking system they were ranked as: 1-AZADI 2-7TIR 3- SADEGHIEH 4- VAHDAT. The traditional ranking model is based on annual portfolio of each branch shown in figure 2.and table 7 shows the priorities of alternatives and criteria based on mathematically proposed model which proved that

there was a significant difference between the traditional ranking model and the engineering proposed model.

traditional assessment
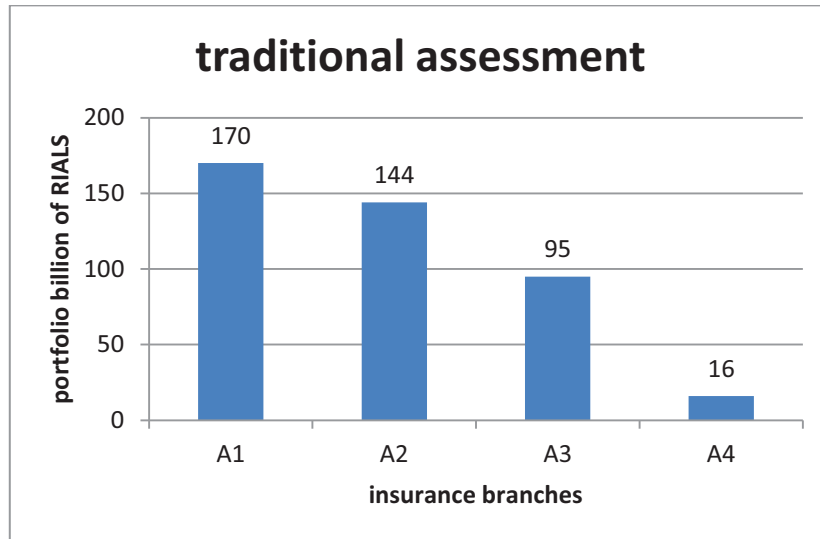
Figure 2.traditional assessment and ranking system of insurance branches
(portfolio billion of RIALS)

Table 7. Priorities of alternatives and criteria by the proposed engineering model from limit super matrix

Ranking	1	2	3	4	5	1	2	3	4
Elements	C4	C2	C1	C5	C3				
Weights						A1	A4	A3	A2

CONCLUSION

Successful management starts with a proper assessment system that is chosen through a robust evaluation method. Akhlaghiet al in 2012 assessed the quality of educational services in Ahvaz technical college via SERVQUAL model [25]. In 2012 Hakyeon et al proposed a data envelopment analysis (DEA) approach to computation of a measure of overall service quality and benchmarking when measuring service quality with SERVQUAL [26]. Ramon et al in 2012 explored the problem of integrating semantically heterogeneous data (natural language included) from various websites with opinions about e-financial services. They developed an extension of the fuzzy model based on semantic translation (FMST) under the perspective of the service quality (SERVQUAL) stream of research [27].In 2011 yucenur et al proposed a model for selecting of the global supplier by analytical hierarchy process (AHP) and analytical network

process (ANP) based on linguistic variable weight then fuzzy AHP and fuzzy ANP results were compared [28].Yazgan in 2011developed an analytical network process model based on benefit, opportunity, cost, and risk in order to eradicate the weaknesses of traditional methods of Selection of a best dispatching rule based on one or two criteria such as processing time, due date, or manufacturing system information in traditional methods such as mathematical programming, simulation ,and heuristic algorithms weakness such as dispatching rules do not allow the use of multiple criteria for evaluating process, second one is related with not considering most of the manufacturing system information, and the last one deals with selection decision not being a dynamic structure [29].in 2012 Emami et al. presented a methodology utilizing MCDM techniques in order to support decision makers when facing different solutions in strategic management to assess alternatives and then to select the best one [30].

The ANP is a relatively new MCDM method which can deal with many interactions systematically, unlike traditional MCDM methods which are based on the independence assumption. The ANP can be used not only as a way to handle the inner dependences within a set of criteria, but also as a way of producing more valuable information for decision-making this paper proposes a solution based on a combined ANP and the SERVQUAL in a management assessment system This approach helps the decision-making team to have a proper solution in management and ranking system. The results of this study showed that not only there was a gap in service quality from the policyholder views but also there was a significant difference between traditional assessment of branches and the mathematically proposed model. So in brief After conducting the SERVQUAL model, it was revealed that service quality functioning of branches in the five dimensions was slightly below the mean and that there was a gap between the perception of the present situation and expectations from the viewpoints of the policy holders and the method of evaluating the branches is not an efficient method which should be converted to a scientific model if the insurance companies want to be efficient and effective in order not to lose their market shares.

Fuzzy numbers would be adopted in Servqual dimension or fuzzy ANP can be utilized to produce a better assessment.

ACKNOWLEDGEMENTS

REFERENCES

1. Whitaker, R., (2007), Validation examples of the Analytic Hierarchy Process and AnalyticNetwork Process,Mathematical and Computer modeling.46, 840–859.
2. Saaty, T.L.,Khouja, M.W., (1976), A measure of world influence, Journal of Peace Science (spring)
3. Saaty. T.L, (1980). The Analytic Hierarchy Process, McGraw-Hill, New York.
4. ForoughiAbari A.A, Yarmohammadian M.H, Esteki.M, (2011), Assessment of quality of education a non-governmental university via SERVQUAL model, Procedia Social and Behavioral Sciences 15 2299–2304.
5. Gale BT. (1994) managing customer value: Creating quality and service that customers can see, New York: The Free Press.
6. Parasuraman A, Zeithaml VA, Berry LL. (1988) SERVQUAL: A multiple item scale for measuring consumer perceptions of service quality. J Retailing; 65; 12-40.
7. Ladhari R. (2009), A review of twenty years of SERVQUAL research. Int. J Qual. Service Sci., 1; 172-198.
8. Cooper WW, Seiford LM, Tone K. (2000) Data envelopment analysis: theory, methodology, and applications, references and DEA-solver software, Boston: Kluwer Academic Publishers.
9. BMI annual report, Rate of insurance industry in IRI GNP, Journal of economics, (2011), 2324(12) (in Persian)
10. Capar, N., Kotabe, M., (2003).The relationship between international diversification and performance in service firms. Journal of international business studies 34,345–355.
11. Parente .R, Byeongyong P.C, Arjen H.L, SlangenS.K, (2010), Distribution system choice in a service industry: An analysis of international insurance firms operating in the United State, Journal of International Management 16 275–287.
12. Gaglianoo, K. B. &Hathcot, J. (1994). Customer expectation and perceptions of service quality in apparel retailing .Journal of service marketing, 8(1); 66-69
13. Parasuraman A, Zeithaml VA, Berry LL. (1985) A conceptual model of service quality and its implications for future research. J Marketing; 49; 41-50.
14. Parasuraman, A., Zeithaml, V. & Berry, L. L. (1991). Refinement and reassessment of the SERVQUAL scale .Journal of Retailing, 67(4), 420- 450.
15. Parasuraman, A., Zeithaml, V. & Berry, L. L. (1994). Alternative scale for measuring service quality: a comparative assessment based on psychometric and diagnostic criteria .Journal of retailing, 70, 207-230.
16. Chung S.H., Lee A.H.L., Pearn W.L.,(2005) Analytic network process (ANP) approach for product mix planning in semiconductor fabricator, International Journal of Production Economics 96 15–36.
17. Figueira J. Salvatore G, Matthias E, (2005), multiple criteria decision analysis, Springer

18. Saaty, T. L. (1996).*The analytic network process-decision making with dependence and feedback*.Pittsburgh, PA: RWS.

19. Buckley, J. J. (1985).Fuzzy hierarchical analysis.*Fuzzy Sets and Systems*, *17*, 233–247.

20. Meade, L. M., &Sarkis, J. (1998). Strategic analysis of logistics and supply chain management systemsusing the analytic network process. *Logistics and Transportation Review*, *34*(2), 201–215.

21. Tseng, M. L., Lin, Y. H., Chiu, A. S. F., & Liao.H. (2008). Using FANP approach on selection ofcompetitive priorities based on cleaner production implementation: A case study in PCB manufacturer,Taiwan. *Clean Technology and Environmental Policy*, *10*(1), 17–29.

22. Sarkis, J. (1999).A methodological framework for evaluating environmentally conscious manufacturing programs.*Computers & Industrial Engineering*, *36*(4),793–810.

23. Lapin L. (1990) probability and statistics for modern engineering, PWS-KENT publishing co. BOSTON.

24. Meade L.M., Sarkis J., (1999) Analyzing organizational project alternatives for agile manufacturing processes: an analytical network approach, International Journal of Production Research 37 241–261.

25. Akhlaghi E., Amini S., Akhlaghi H.(2012), Evaluating educational service quality in technical and vocational colleges using SERVQUAL model, Procedia - Social and Behavioral Sciences 46, 5285 – 5289

26. Hakyeon. L., Chulhyun K., (2012) A DEA-SERVQUAL Approach to Measurement and Benchmarking of Service Quality, Procedia - Social and Behavioral Sciences 40; 756 – 76.

27. Ramon A. C., Munoz-L.F., Sanchez .J.-Fernandez B ,Francisco J. Liebana C. (2012) A model for the integration of e-financial services questionnaires with SERVQUAL scales under fuzzy linguistic modeling, Expert Systems with Applications 39 11535–11547

28. Yucenur.G.N.&Vayvay. O.&Demirel N.Ç,(2011), Supplier selection problem in global supply chains by AHP and ANP approaches under fuzzy environment, Int. J Adv Manuf. Technol. 56:823–833

29. Yazgan H.R,(2011), Selection of dispatching rules with fuzzy ANP approach, Int. J Adv Manuf. Technol. 52:651–667

30. Emami.M, Nazari.K, Fardmanesh.H,(2012) Application of Fuzzy TOPSIS Technique for Strategic Management Decision, *Journal of Basic and Applied Scientific Research2(1)685-689.*

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PROCESS MODEL DISCOVERY BASED ON ACTIVITY LIFESPAN

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ABSTRACT

Most process discovery methodologies are based on a technique that focuses on the single-point timestamp of an event. This paper introduces an alternative methodology that discovers process models by considering an activity and its duration (i.e., lifespan). We define six types of temporal causal relations between activities as extension of basic log-based relations; we introduce a concept of "non-linear dependency" in order to enable the relations in process instances to cope with activity lifespan control flows, and we propose an algorithm for process model discovery based on activity lifespan. Additionally, we demonstrate our proposed methodology on the basis of real-world block assembly data obtained from a shipbuilding company.

Keywords. Process discovery, activity lifespan, time-based interval, block assembly process, process mining, BPMN 2.0

INTRODUCTION

Most process model discovery methodologies are based on a technique that focuses on the single-point timestamp of an event rather than an activity and its duration ([7], [8], [9], [10], etc.). Consequently, the discovered process model shows a precedence network not of activities but of events. Even some process discovery algorithms considering event types discover a process model consisting of *Start* and *Finish* event ([7], [8]). In order to generate, using traditional process model algorithms, a process model consisting of activities with lifespan,

only *Finish* event type has been considered; thereby, however, the discovered process model has become less precise.
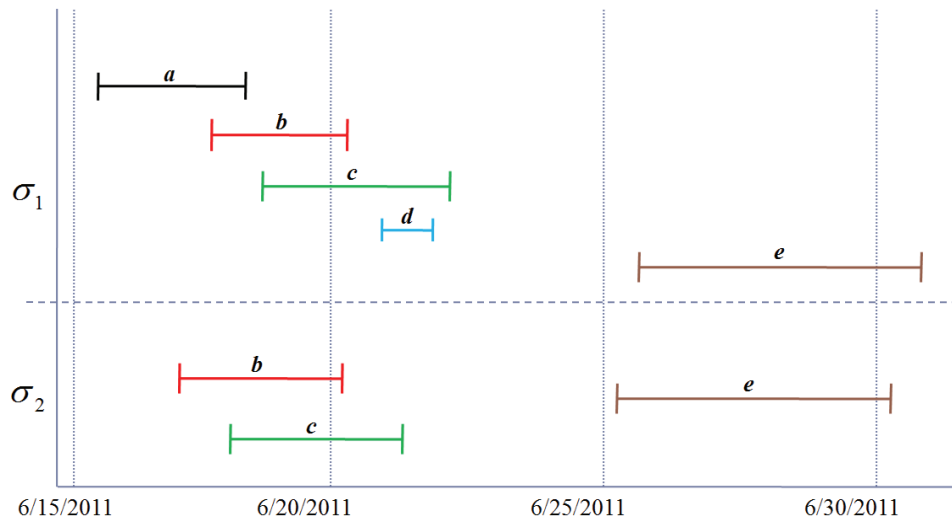
Figure 1: Sample traces plotted on Gantt chart

As an example of our approach, let us consider Figure 1, which shows two sample traces of five activities and their respective execution durations (e.g., the start, denoted (*Start*), and finish, denoted (*Finish*) duration of each activity represents the start and finish activity, respectively). Figure 2 illustrates the process model discovered from these traces Heuristics Miner [7] in BPMN 2.0. In this process model (see Figure 2(a)), we find that event *b*(*Start*) is parallel to event *a*(*Start*) and event *a*(*Finish*). However, according to Figure 1, we can argue that activity *a* (containing event *a*(*Start*) and event *a*(*Finish*)) should be parallel to activity *b* ((containing event *b*(*Start*) and event *b*(*Finish*)), nonetheless we see only a partial parallelism between activity *a* and activity *b* (see event *b*(*Start*)). Alternatively, using only the *Finish* event type, we can discover the process model shown in the Figure 2(b). There, we see the resemblance to the Figure 2(a) process model, but we cannot see that activity *a* is parallel to b, and, moreover, we cannot see the parallel relation between activities *c* and *d*, which is clearly seen in Figure 1. As noted in [12], the traditional algorithms follow the principle of "linear dependency" between all activities regardless of the event type (e.g., activity *e* depends on *d*, *d* on *c*, *c* on *b*, and *b* on *a*); therefore, to resolve this linear problem, it is important to find the process model based on the activity precedence relation.
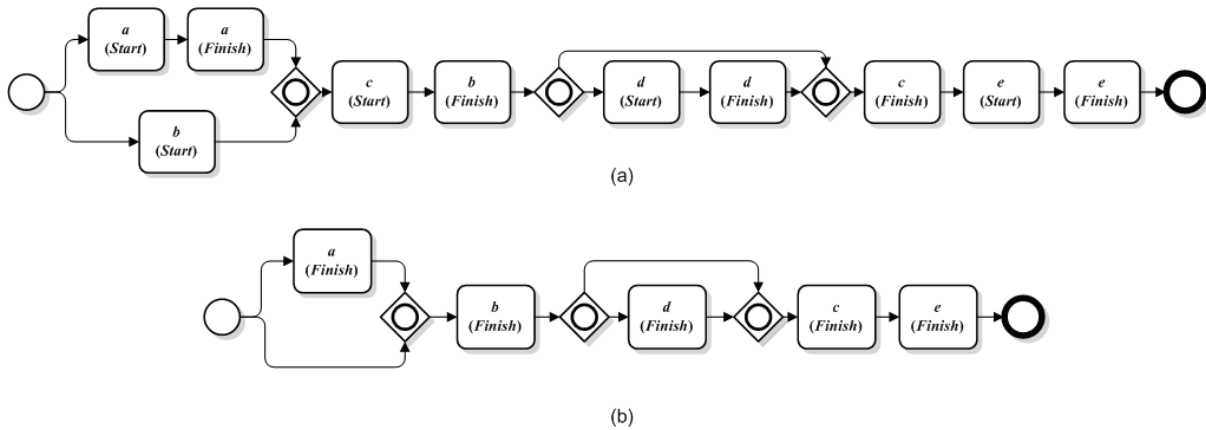
Figure 2: Process model discovered from Figure 1 using Heuristic Miner in BPMN 2.0: (a) all event types; (b) only *Finish* event type

Let us again consider the chart in Figure 1. At a glance, we can easily determine that from first trace (σ_1), activities *a* and *b* should be in parallel relation (as should activities *c* and *d*); and that accordingly, activity *a* will be followed by activity *c* and *d*, activity *b* will be followed by activity *d*, and, finally, activity *c* and *d* will converge to activity *e*. Figure 3, illustrating the traces (Figure 3(a): trace σ_1, and Figure 3(b): trace σ_2) as modeled in BPMN 2.0, shows clearly the relations between activities. From this different perspective, we try to model a process instance as a variant of business process execution before finding the consolidated process model.
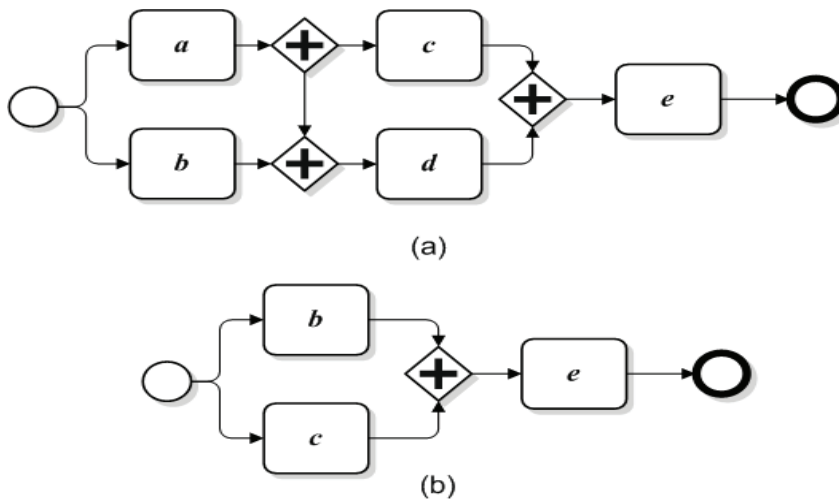
Figure 3: Traces in Figure 1 modeled in BPMN 2.0 as variants of process executions:

(a) σ_1, (b) σ_2
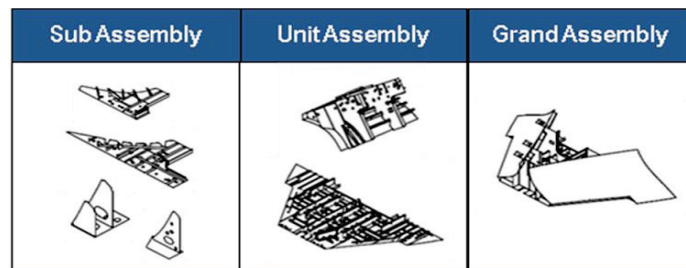
Figure 4: Block assembly plates in Shipbuilding Company

In this paper, we briefly discuss a new perspective on, and approach to, process model discovery. We first define the notion of process lifespan, and we then discuss the representation of a process instance as a variant of the process model. Finally, we present a method for building the consolidated process model. Additionally, we demonstrate the applicability of our methodology on the basis of real-world data obtained from a shipbuilding company. The data, as shown in Figure 4, is for a block assembly process consisting of Unit Assembly, Sub-Assembly block and Grand Assembly. A block assembly process is a tree-like process wherein a part is the smallest portion of steel plate (not shown in the figure), and several parts welded together compose a larger portion of plate (a block assembly); the final, Grand Assembly is composed of several Sub Assemblies and Unit Assemblies. Each work stage in the block assembly process is considered as an activity. This paper is organized as follows: section 2 discusses the related work; sections 3 and 4 introduce the process discovery method and a case study, respectively, and section 5 draws conclusions.

RELATED WORK

Several studies relevant to process model discovery from activity lifespan have been completed ([1], [2], [3], [11],[12]). According to Pinter and Golani [1], the lifespan of an activity is its time duration from start to finish. The extended lifespan of an activity is its time duration from "ready to execute" to start and, finally, to finish. The procedure is as follows: 1) for each trace, a trace graph resembling the process execution is drawn; 2) all of the trace graphs are then merged following a heuristics rule that considers the recall and precision measurement of the resulting merged graph according to all of the traces in the logs; 3) the merged-graph result is then represented using a directed acyclic graph. Unfortunately, this method can be an impracticably exhaustive process for building each trace graph, since, for any real-world process, there are possibly thousands of traces in the logs. Tsai et al. [2] introduced a method of time-interval process model discovery that discretizes activity lifespan into a categorical type and uses a genetic algorithm to find the optimal graph. This method takes into account accuracy and precision to calculate fitness. The resulting process, however, is not easy to interpret, since each of the discretized activity lifespans is included in the process model. Similarly, Werf et al. [3] discretized activity lifespan into a categorical type in order to mine declarative models in consideration of the time interval. Their method first maps each event to an interval, and then maps the interval to the user's preferred granularity. Subse-

quently, it derives the relation of causality and simultaneousness, and, finally, draws the graph. Interval granularity selection though can be tricky, because it can influence the resulting process model.

Aalst et al.[6] introduced four basic log-based ordering relations that exist between two events, namely causal relation, direct causal relation, parallel relation and not-related. These are used as the α-algorithm foundation; however, they take into account only a single-point timestamp, not duration. Wen et al. [11], on the other hand, incorporated event duration to mine a process model from an event log, which method was applied to Structured Workflow network (SWF-net). This approach incorporates two-basic-log-relations, succession and intersection. Burattin and Sperduti [12] introduced an extension of Heuristic Miner that considers activity lifespan. Their scheme combines, to a certain degree, activities containing a single-point timestamp with those containing duration.

In the field of business process model management research, process model collections, according to [13], are often the result of organizational mergers or acquisitions. Each process model collection consists of several process variants. Meanwhile, a process model consolidation (or process model reference) is a process model that represents its variants. Many papers have discussed how to consolidate process variants ([15] [16], etc.), mostly by merging them into a single process model reference.

Djikman et al. [13] classified the process model merging techniques into three classes: (1) Process behavior, (2) Label similarity, and (3) Language. In the first classification, a process model reference should be able to represent its variants after it is consolidated. In other words, each behavior represented in process variants should be able to be replayed in the process model reference. Contrastingly, in the second classification, enforcing the behavior-preservation is not required, thus it is not guaranteed that each behavior can be replayed in the process model reference. The third classification restricts process merging to the language used in the process variants (e.g., EPC). Therein, label similarity between activities can be disregarded, since one activity throughout an event logs has similar labels (and so does the process model language to represent it). However, a node-mapping mechanism is still necessary. Hence, in our methodology, process behavior similarity is the utmost importance process model merging protocol.

One of the most common approaches to process variant merging ([14], [15], etc.) is as follows: (1) Mapping nodes between process variants, (2) Finding the merge region, and, finally, (3) Merging the process variants. The mapping of nodes between process variants is closely related to the finding of node similarity between variants (i.e., the merge region), in the sense of the semantic similarity [15]. Finding the merge region is to find the dissimilarity region, which can be the candidate for merging. Lastly, to merge process variants, a versioning is supposed to be maintained, whereby the origin of the process variant can be traced back from the consolidated process model.

In the process mining field, a multi-phase aggregating technique similar to process variant merging has been introduced [16]. This represents each instance as a directed graph, and aggregates it into a single process model. Unlike process variant merging, however, the multi-phase aggregating technique does not incorporate a multiple timestamp as a single activity (e.g., as a *Start* and *Finish* event).

PROCESS DISCOVERY

Activity lifespan and temporal causal relation
A hierarchical event log process was first introduced by Aalst [4]. On the basis of their notation, here, we define several terms that will be used with a process discovery algorithm and process model according to the concept of activity lifespan. As described in their work [4], we assume that there is a set of activities $\mathcal{A}$, which contains a set of activities in event logs.

In the current process mining algorithms, a precedence relation between events is discovered instead of a precedence relation between activities. The previous algorithms show an event with different event types as two separate activities. As defined in [11], a process model consists of a set of activities and the execution constraint between them. Accordingly, in the methodology introduced in this paper, the process discovery algorithm basically finds the sequential relations among activities $A \subseteq \mathcal{A}$. Here, we assume an event to be an activity that has a start and a finish time.

Definition 1. Event. In an event set E, an event $e \in E$ can have attributes such as event name, event type, timestamp, originator and other data attributes, denotes as $\#_{name}(e)$, $\#_{type}(e)$, $\#_{time}(e)$, $\#_{originator}(e)$, and $\#_{data}(e)$, respectively.

Definition 2. Activity. In an activity set A, an activity $a \in A$ is related to a pair of events $a(e_s, e_f)$, where e_s is a *Start* event and e_f is a *Finish* event.

Definition 3. Event Logs. Given event log $L=[\sigma_1, \sigma_2, \ldots, \sigma_I]$, a trace σ_i, consists of a series of events, such that $\sigma_i=<e_1, e_2, \ldots, e_J>$. Each event is either a *Start* event or a *Finish* event.
Similarly to an event, an activity also can have attributes. According to the original process mining terms however, only an event can have attributes. In this paper, we explicitly define activity attributes, for instance the single activity name and originator, while the event types have two values, as stated in Definition 1: *Start* event and *Finish* event. When we address the attributes of an activity and event, we use the same notation #. For example, activity name is presented as $\#_{name}(a)$, and event type as $\#_{type}(e)$.

Definition 4. Activity Lifespan. The activity lifespan is defined as a combination of its *Start* event and *Finish* event, and is denoted as $a(e_s, e_f)$. Activity lifespan has its duration

$d(a) = [t_s, t_f]$, where $t_s = \#_{time}(e_s)$, $t_f = \#_{time}(e_f)$, and $t_s < t_f$ such that its start time is always prior to its finish time.

To differentiate a temporal causal relation between two activities, we used the normalized temporal patterns provided in Winarko and Roddick [5]. As shown in **Figure 5**, these patterns consist of seven relations, namely, *before*, *meets*, *overlaps*, *is-finished-by*, *contains*, *equals*, and *starts*. As the figure indicates, a sequence relation is more likely to be a *before* and *meets* temporal relation, whereas a parallel relation is more likely to be another temporal relation. Based on this assumption, we give a formal definition of temporal causal relations and control flows.

Definition 5. Temporal Causal Relations. Given event log L and trace σ such that $\sigma \in L$, the temporal causal relation between two activities, $a(e_s, e_f)$ and $b(e_{s'}, e_{f'})$, according to which $a, b \in A$ can be differentiated as follows:

1. *Before* and *meets*, $a >_L b$ iff $t_f \leq t_{s'}$
2. *Overlaps*, $a \square_L b$ iff $t_f > t_{s'}$ and $t_f < t_{f'}$
3. *Is-finished-by*, $a f_L b$ iff $t_f = t_{f'}$ and $t_s < t_{s'}$ and $t_{s'} < t_f$
4. *Contains*, $a @_L b$ iff $t_s < t_{s'}$ and $t_f > t_{s'}$ and $t_f > t_{f'}$
5. *Equals*, $a \lozenge_L b$ iff $t_s = t_{s'}$ and $t_f = t_{f'}$
6. *Starts*, $a p_L b$ iff $t_s = t_{s'}$ and $t_f > t_{f'}$.

Temporal causal relation (1), which represents both *before* and *meets*, is an extension of the basic log-based ordering relation described in [6]. As for parallel relation, we classify them as *overlaps* (2), *is-finished-by* (3), *contains* (4), *equals* (5), and *starts* (6).

Definition 6. Control Flows. Given event log L and trace σ such that $\sigma \in L$. A control flows of two activities, $a(e_s, e_f)$ and $b(e_{s'}, e_{f'})$, such that $a, b \in A$ is formalized as follows:

1. *Sequence*, $a \rightarrow_L b$ iff $a >_L b$ and $b \square_L a$
2. *Not related*, $a \#_L b$ iff $a \square_L b$ and $b \square_L a$
3. *Parallel*, $a \|_L b$ iff $a >_L b$ and $b >_L a$ or $\{ a \square_L b$ or $a f_L b$ or $a p_L b$ or $a @_L b$ or $a \lozenge_L b \}$
4. *Parallel Disjunctive*, $a \oplus_L b$ iff $a \|_L b$ and there exist $c \in A$ where $a >_L c$ or $b >_L c$ in any $\sigma \in L$
5. *Parallel Conjunctive*, $a \otimes_L b$ iff $a \|_L b$ and there exist $c \in A$ where $a \square_L c$ or $b \square_L c$ in any $\sigma \in L$.

The sequence relation in each process instance is denoted as $\rightarrow_{\sigma_i}$.
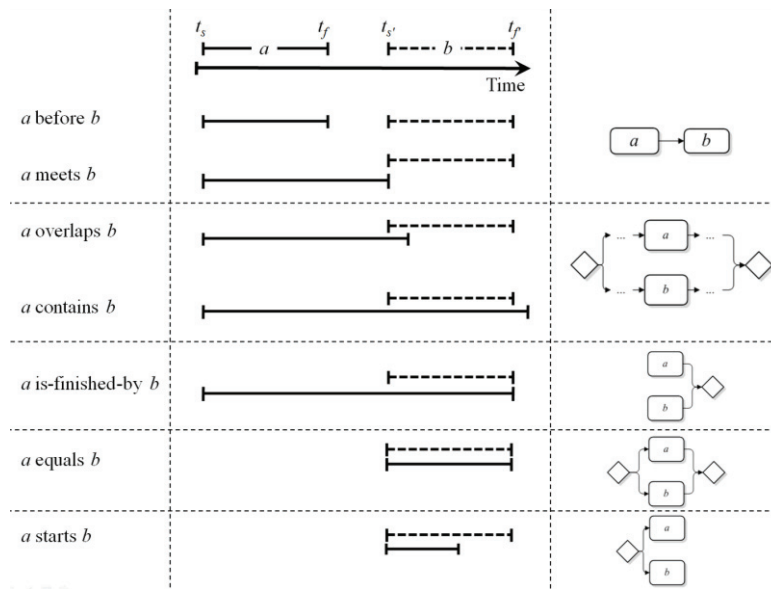
Figure 5: Seven normalized temporal patterns

Process instance as variant of process model execution

Process variants, according to [13], are often the results of organizational mergers or acquisitions. A process variant contains control flows similar to those of a process model (i.e., sequence and parallel). In process mining terminology, if we look closely in respect to the lifespan of an activity, we often find that in a process instance there is a parallel relation between activities. However, as stated in [12], the current developed process discovery algorithms follow linear dependency, wherein activities in a process instance are likely to have sequential relations (see **Figure 6**). A parallel relation, on the other hand, is seen as the alternating relationship of two activities (e.g. the parallel relation of $a \parallel_L b$ iff $a >_L b$ and $b >_L a$ for $a,b \in A$) among process instances. In this paper, we propose the concept of "non-linear dependency", according to which, a process instance, like a process variant, can contain parallel relations. By extending the notion of sequence relation in Definition 6., we give a formal definition related to non-linear dependency for each process instance.

Definition 7. Non-linear Dependency in a Process Instance. Given event log L and trace σ such that $\sigma \in L$, a sequence relation $a \rightarrow_L b$ and $a \rightarrow_L c$ between activities $a(e_s, e_f)$, $b(e_{s'}, e_{f'})$, and $c(e_{s''}, e_{f''})$, such that $a,b,c \in A$ if $a >_L b$, $a >_L c$, and $b \parallel_L c$. As well as, a sequence relation $b \rightarrow_L d$ and $c \rightarrow_L d$ between activities $b(e_{s'}, e_{f'})$, $c(e_{s''}, e_{f''})$, and $d(e_{s'''}, e_{f'''})$, such that $a,b,c \in A$ iff $b >_L d$, $c >_L d$, and $b \parallel_L c$

Referring to **Figure 6** as an example, if we apply linear dependency, the relations in instance σ would be $a \rightarrow_L b, b \rightarrow_L c, c \rightarrow_L d$, and $d \rightarrow_L e$, which do not convey the real execution result of instance σ in the figure. However, using non-linear dependency, the relations in instance σ would be $a \rightarrow_L b$, $a \rightarrow_L c$, $b \rightarrow_L d$, $c \rightarrow_L e$ and $d \rightarrow_L e$, with additional parallel rela-

tions $b \|_\sigma c$ and $d \|_\sigma c$ (for more example, see **Figure 3**). Here, we can see that non-linear dependency captures more relations than linear dependency in representing the real execution in respect to activity lifespan.
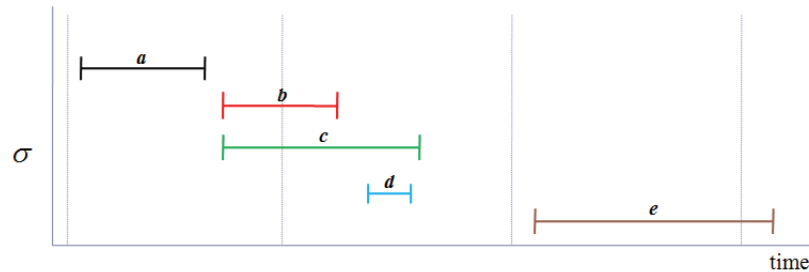
Figure 6: Trace showing non-linear dependency

Currently, we have a set of process variant representation-like for each process instance. Since the number of process instances in an event log can be hundreds or thousands, it is an onerous work to merge process instances in the manner of process variants. It should be noted that before merging two process variants, we need to match the label and behavior similarity between them. In general, the time complexity of finding the bias and distance of two process models can be as complex as an NP problem [18]. As introduced in [17], the time complexity of static matching, $O(n_1 \times n_2)$, and of behavioral matching, $O(y \times m_1 \times m_2)$, for any two input models, where n_1 and n_2 are the numbers of nodes, m_1 and m_2 are the number of arcs, and y is the maximum allowed number of iterations for the behavioral matching algorithm. Therefore, in our proposed methodology, in place of the merging technique, we use a set operation to derive the process model.

Process discovery algorithm
This section describes the steps taken by the process discovery algorithm using control flow as defined in the previous section. The several steps are, first, listing of all input and output activities for each trace; then, the classification of a sequence, parallel disjunctive and parallel conjunctive relation, and finally, the display of the complete set of relations of activities in the event log.
Figure 7 shows the complete process model discovery algorithm.

Algorithm 1 TemporalActivity-BasedProcessDiscovery(L)

Input: an event logs L

Output: a graph $G_L(N_L, E_L)$

Initialize

    T_I : a list of first activities in L;

    T_O : a list of last activities in L;

    N_L : a set of nodes comprised of activities and gateways (i.e., parallel disjunctive and parallel conjunctive)

    $E_L = \{< (\{a,b,...\},\{c,d,...\}), cf >\}$: a list that contains a pair of activities and its control flow, cf

    imd : a temporary variable containing an immediate activity

    i: integer counter

For each $\sigma \in L$ **do**

  For each pair of activities $a(e_s, e_f) \in \sigma$ **do**

    If a is not in N **then** $N \leftarrow N \cup \{a\}$ **End**

    For each pair of activities $b(e_{s'}, e_{f'}) \in \sigma$ preceding $a(e_s, e_f)$ **do**

      If b is not in N **then** $N \leftarrow N \cup \{b\}$ **End**

      If isFirst (a) and a is not in T_I **then** $T_I \leftarrow T_I \cup \{a\}$ **End**

      If isLast (b) and b is not in T_O **then** $T_O \leftarrow T_O \cup \{b\}$ **End**

      If $a >_\sigma b$ and (a,b) not in $>_\sigma$ **then**

        $>_\sigma \leftarrow >_\sigma \cup (a,b)$

        $imd \leftarrow b$

      Else if $imd \parallel_\sigma b$ and $a \square_\sigma imd$ and $imd \square_\sigma b$ and $a \neq_\sigma b$ **then**

        $>_\sigma \leftarrow >_\sigma \cup (a, imd)$

        if $b >_\sigma imd$

          $imd \leftarrow b$

      Else //either $a \square_\sigma b$, $a f_\sigma b$, $a @_\sigma b$, $a p_\sigma b$, or $a \Diamond_\sigma b$ or ($a >_\sigma b$ and $b >_\sigma c$)

        $\parallel_L \leftarrow \parallel_L \cup (a,b)$

    End

  End

End

For each $>_{\sigma_i} \in >_\sigma$ **do**

  For each $(a,b) \in >_{\sigma_i}$ **do**

    if (a,b) is not in $>_L$ **then** $>_L \leftarrow >_L \cup (a,b)$ **End**

  End

End

For each $(a,b) \in \parallel_L$ **do**

    If $a \oplus_L b$ and (a,b) not in $\oplus_L$ **then**

      $\oplus_L \leftarrow (a,b)$

    Else if $a \otimes_L b$ and (a,b) not in $\otimes_L$ **then**

      $\otimes_L \leftarrow (a,b)$

    End

End

$i \leftarrow 1$

Find $(c,d) \in >_L$ in which d contains a or b , where $(a,b) \in \oplus_L$

  If $\oplus_L$ is not empty and $\oplus_i$ is not in N **then** $N \leftarrow N \cup \{\oplus\}$ **End**

  $E_L \leftarrow E_L \cup \{< (\{c\}, \oplus_i), \rightarrow >\}$

  $E_L \leftarrow E_L \cup \{< (\oplus_i, \{a,b\}), \rightarrow >\}$

  $i \leftarrow i + 1$

End

Find $(c,d) \in >_L$ in which c contains a or b , where $(a,b) \in \oplus_L$

  If $\oplus_L$ is not empty and $\oplus_i$ is not in N **then** $N \leftarrow N \cup \{\oplus\}$ **End**

$E_L \leftarrow E_L \cup \{<(\{a,b\}, \oplus_i), \rightarrow>\}$

$E_L \leftarrow E_L \cup \{<(\oplus_i, \{d\}), \rightarrow>\}$

$i \leftarrow i+1$

$>_L \leftarrow >_L \setminus (c,d)$

End

$i \leftarrow 1$

Find $(c,d) \in >_L$ in which d contains a or b, where $(a,b) \in \otimes_L$

    If $\otimes_L$ is not empty and $\otimes_i$ is not in N **then** $N \leftarrow N \cup \{\otimes\}$ **End**

    $E_L \leftarrow E_L \cup \{<(\{c\}, \otimes_i), \rightarrow>\}$

    $E_L \leftarrow E_L \cup \{<(\otimes_i, \{a,b\}), \rightarrow>\}$

    $i \leftarrow i+1$

End

Find $(c,d) \in >_L$ in which c contains a or b, where $(a,b) \in \otimes_L$

    If $\oplus_L$ is not empty and $\oplus_i$ is not in N **then** $N \leftarrow N \cup \{\oplus\}$ **End**

    $E_L \leftarrow E_L \cup \{<(\{a,b\}, \otimes_i), \rightarrow>\}$

    $E_L \leftarrow E_L \cup \{<(\otimes_i, \{d\}), \rightarrow>\}$

    $i \leftarrow i+1$

    $>_L \leftarrow >_L \setminus (c,d)$

End

For each $(a,b) \in >_L$ **do**

    If (a,b) is not in E_L **then** $E_L \leftarrow E_L \cup \{<(\{a\}, \{b\}), \rightarrow>\}$ **End**

End

For each $a \in T_I$ **do**

    $E_L \leftarrow E_L \cup \{<(\{\}, \{a\}), \rightarrow>\}$

End

For each $a \in T_O$ **do**

    $E_L \leftarrow E_L \cup \{<(\{a\}, \{\}), \rightarrow>\}$

End

Figure 7: Mining lifespan algorithm

Now, let us apply this algorithm to the traces in Figure 1:

$T_I = \{a,b,c\}$

$T_O = \{e\}$

$>_{\sigma_1} = \{<\{\}, \{a\}>, <\{a\}, \{c\}>, <\{a\}, \{d\}>, <\{\}, \{b\}>, <\{b\}, \{d\}>, <\{c\}, \{e\}>, <\{d\}, \{e\}>\}$

$>_{\sigma_2} = \{<\{\}, \{b\}>, <\{\}, \{c\}>, <\{b\}, \{e\}>, <\{c\}, \{e\}>\}$

$>_L = \{<\{\}, \{a\}>, <\{\}, \{b\}>, <\{\}, \{c\}>, <\{a\}, \{c\}>, <\{a\}, \{d\}>, <\{b\}, \{d\}>, <\{b\}, \{e\}>, <\{c\}, \{e\}>, <\{d\}, \{e\}>\}$

$\|_L = \{<\{a\}, \{b\}>, <\{b\}, \{c\}>, <\{c\}, \{d\}>\}$

$\oplus_L = \{<\{a\}, \{b\}>, <\{b\}, \{c\}>, <\{c\}, \{d\}>\}$

$\otimes_L = \{\}$

$N_L = \{a,b,c,d,e, \oplus_1, \oplus_2, \oplus_3\}$

$E_L = \{<\{\}, \{a\}, \rightarrow>, <\{\}, \{b\}, \rightarrow>, <\{\varnothing, a\}, \{\oplus_1\}, \rightarrow>, <\{\oplus_1\}, \{c, \oplus_2\}, \rightarrow>, <\{b\}, \{\oplus_2\}, \rightarrow>,$
$<\{\oplus_2\}, \{d, \oplus_3\}, \rightarrow>, <\{c, d, \oplus_2\}, \{\oplus_3\}, \rightarrow>, <\{\oplus_3\}, \{e\}, \rightarrow>, <\{e\}, \{\}, \rightarrow>\}$

$G_L = (N_L, E_L)$

Figure 8: Process model discovery of traces in Figure 1

Figure 8 presents the process model in the BPMN 2.0 form for traces just computed. In the process model, activities *c* and *d* are clearly in the parallel disjunctive state, since there are traces showing that activity *a* can follow activity *c* without the occurrence of activity *d* in the same trace. This model also shows one activity for two events, and, thus, simplifies the process model shown in Figure 2.

Behavioral and Structural Appropriateness

To validate our proposed methodology, we use two kinds of scoring, which measure both the behavioral and structural appropriateness between an event log and the discovered process model. To those end, we modified the appropriateness concept ([19], [20]), in accordance with the activity lifespan.

Measure 1. Behavioral Appropriateness. Let *G* be a process model over event log *L* such that there exist a set of sequence and parallel relations for process model G and event log L, denoted as $\rightarrow_G$ and $\rightarrow_L$ for the sequence relation, and $\|_G$ and $\|_L$ for the parallel relation. The behavioral appropriateness measure is calculated as

$$b(G,L) = \frac{|\rightarrow_G \cap \rightarrow_L| + |\ \|_G \cap \|_L\ |}{|\rightarrow_G \cup \rightarrow_L| + |\ \|_G \cup \|_L\ | + 1}.$$

Measure 2. Structural Appropriateness. Let *G* be a process model over event log *L* such that there exists a set of activities mappings for activities in event log *L* to process model *G*, denoted as N_L, and a set of nodes in the process model *G* (e.g., activities and gateways), denoted as N_G. A factor of 2 is added to accommodate the insertion of artificial *Start* and *End* nodes in the process model. The behavioral appropriateness measure is calculated as

$$s(G,L) = \frac{|N_L| + 2}{|N_G|}.$$

As an example,

Figure 8 has a behavioral appropriateness score of $\frac{7+3}{7+3+1} \approx 0.9$ and structural appropriateness score of $\frac{5+2}{10} \approx 0.7$.

CASE STUDY

Shipbuilding process

A shipbuilding process consists mainly of eight sub-processes, which are designing, steel stocking, cutting and forming, assembling, pre-outfitting and painting, pre-erection, docking, and quay side processing (outfitting, painting, and sea trials). Completion of an entire process might require one year. We limited our case study to the assembly process. This process, which we call block assembly, entails the welding together portions of steel to construct a larger section.

Figure 9 shows the structure of the block assembly process assumed in this study. The block assembly activities are considered to be the work stages, namely Sub Assembly, Unit Assembly and Grand Assembly. Unit assembly is further classified into tree types: small, curved and large. Therefore, there are five work stages shown in Figure 9: Grand Assembly (Grand_Assy.), Unit Assembly of Small Type (Unit_Assy.(S)), Unit Assembly of Curved Type (Unit_Assy.(C)), Unit Assembly of Large Type (Unit_Assy.(L)), and Sub Assembly (Sub_Assy.). Each work stage involves manipulation of small plates, called "parts," which are omitted from the process model schematic.
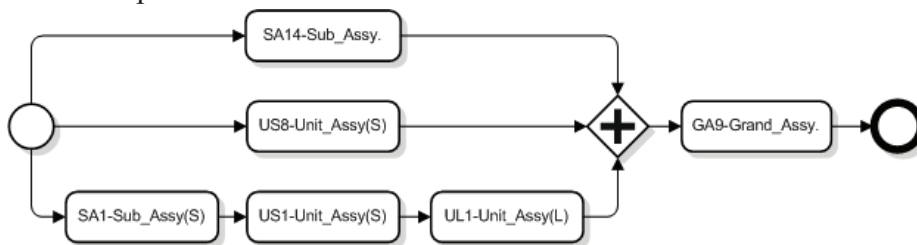
Figure 9: Process model of block assembly process in shipbuilding company

As common to any manufacturing industry, first, a scheduled process is laid out, and then the execution is performed based on that schedule. However, block assembly process monitoring is complex. As seen in **Figure 9**, a block assembly process is a composition process, wherein a previous block is completed earlier before incorporation into a larger block. Should the earlier block assembly miss the given scheduled release, the development of the larger block can be sequentially delayed. In this study, process mining was used to analyze what actually happens in a block assembly process in order to evaluate the current flow of blocks and, on that basis, enable more efficient scheduling.

Table 1: Excerpt of event logs of block assembly

Case ID	Assembly Type	Event Type	Start Time
11XX-109	SA1-Sub_Assy.	Start	2011-05-17 17:49
11XX-109	SA1-Sub_Assy.	Finish	2011-05-17 17:49
11XX-109	US1-Unit_Assy.(S)	Start	2011-06-11 10:11
11XX-109	US1-Unit_Assy.(S)	Finish	2011-06-13 13:00
11XX-109	UL1-Unit_Assy.(L)	Start	2011-06-16 09:33
11XX-109	UL1-Unit_Assy.(L)	Finish	2011-06-21 06:42
11XX-109	US8-Unit_Assy.(S)	Start	2011-06-21 09:28
11XX-109	SA14-Sub_Assy.	Start	2011-06-21 09:28
11XX-109	US8-Unit_Assy.(S)	Finish	2011-06-21 13:00
11XX-109	SA14-Sub_Assy.	Finish	2011-06-26 06:47
11XX-109	GA9-Grand_Assy.	Start	2011-06-27 15:47
11XX-109	GA9-Grand_Assy.	Finish	2011-07-01 2:11

Block assembly event log

The block assembly event logs were obtained from Block Assembly Monitoring Systems (BAMS). Such systems record a block assembly process from the planning stage to the actual execution stage. We limited our data to the actual execution stage, which consists of the start and finish event of each work stage.

A shipbuilding company can have multiple projects simultaneously ongoing; for each project, there are about 100 block assemblies, and each block requires three to four months to complete. In our case study, we used an event log consisting of two projects, comprising with 13 activities, 60 process instances and 652 events. To represent a process instance, we combine the values of *Project Number* and *Block Number*; for an activity name, we combine the values of *Work Stage* and *Assembly Type*. Each activity has two event types: *Start* and *Finish*. These event types are used later to determine the duration of the timestamp. Table 1 shows an excerpt of block assembly event log with a process instance.

DISCUSSION

In this section, we compare our proposed methodology with the current available process model discovery algorithm in consideration of activity lifespan, and, we address the future challenges facing its refinement.

Process model discovery

The relevant research on the concept of linear dependency in process discovery, introduced by Burratin and Sperduti [12], is as follows. In [7], the process model discovered according to the relation between two events (instead of activities) as represented by a dependency score, whereas in [9], a level of abstraction is applied to discover the process model based on unary significance, binary significance, and binary correlation score. However, the method also employs a single-point timestamp of an event. An alpha-type algorithm ([6],[8]) is able to group two events having *Start* and *Finish* event types as one activity, though the relation is still between events. An extension of the alpha algorithm, the beta algorithm [11], which considers activity lifespan, also follows the principle of linear dependency.

Burratin and Sperduti [12] enhanced the heuristic miner algorithm to cope with activity lifespan. Although the concept of non-linear dependency was not explicitly stated in their work, it was clear that Burratin and Sperduti considered it to define the relation between two activities. In their work, however, there were a certain percentages in which the activities in the event logs contained duration, whereas the rest still contained the single-point timestamp. We now show our case study's resultant process model which contains 100% activity lifespan, as shown in Figure 10. As indicated, the process model is able to clearly show the control flows between activities and their temporal relations (i.e., parallel and sequence relation).

The discovered process model from the case study had a behavioral appropriateness of $\frac{10+27}{37+27+1} \approx 0.57$ and a structural appropriateness of $\frac{13+2}{19} \approx 0.79$. With this result we can confidently state that the proposed method can discover a process model that represents the event log.

Moreover, based on the process model, the *US4-Unit_Assy.(S)*, *SA7-Sub_Assy.* and *SA8-Sub_Assy.* block assemblies can be considered the critical points of the process model, since those blocks will be used as the starting point for the construction of a larger block. Using similar reasoning, *SA1-Sub_Assy.* and *US1-Unit_Assy.(S)*) block assemblies are also another critical points. Clearly, a planning schedule has to be drawn up carefully so as to avoid any delays.

Challenges

As shown in **Figure 11**, a process model was discovered for an event log comprising 27 activities, 136 cases and 1706 events over a six-month period of observation. With twice the number of activities and cases, and three times the number of events compared with the data

used in the case study, the process model shows a greater degree of complexity that renders analysis by a domain expert difficult. Therefore, a better level of abstraction will be the next issue treated in the ongoing research we are conducting for our proposed methodology.

In the meantime, our approach uses a set operation of a sequence and parallel relation to discover a process model. Thus, noise is not assumed. A relative frequency occurrence, for example, can be used to differentiate noise and non-noise relations. An alternative solution similar to those pursued in [7] and [12] is the use of a dependency threshold for process model discovery, which also can be considered. Another strategy, a fitness measure specifically for activity lifespan was not addressed in this paper.
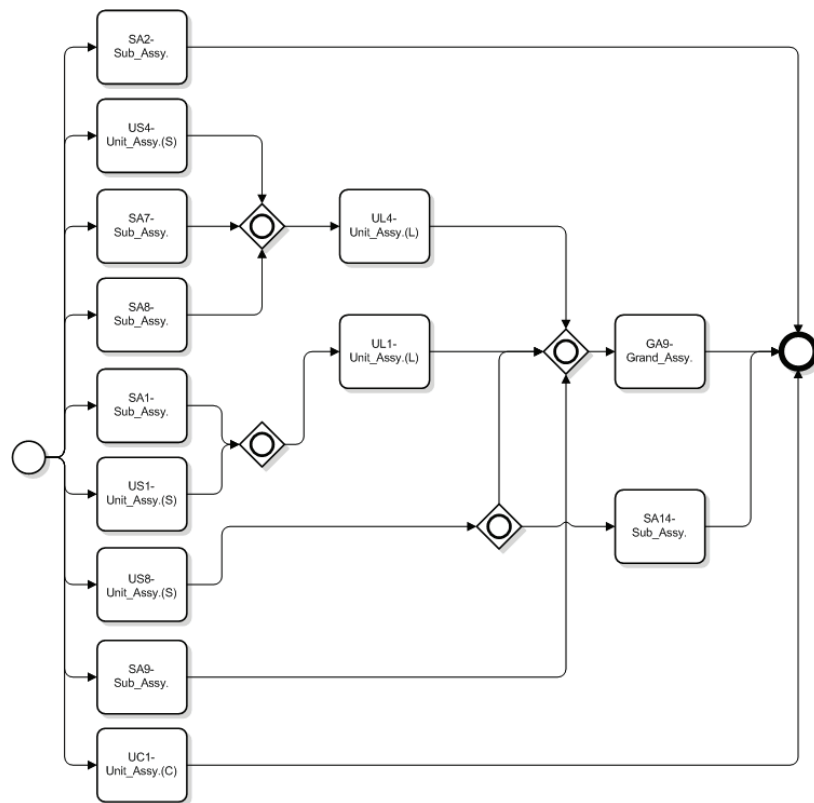
Figure 10: Process model discovered
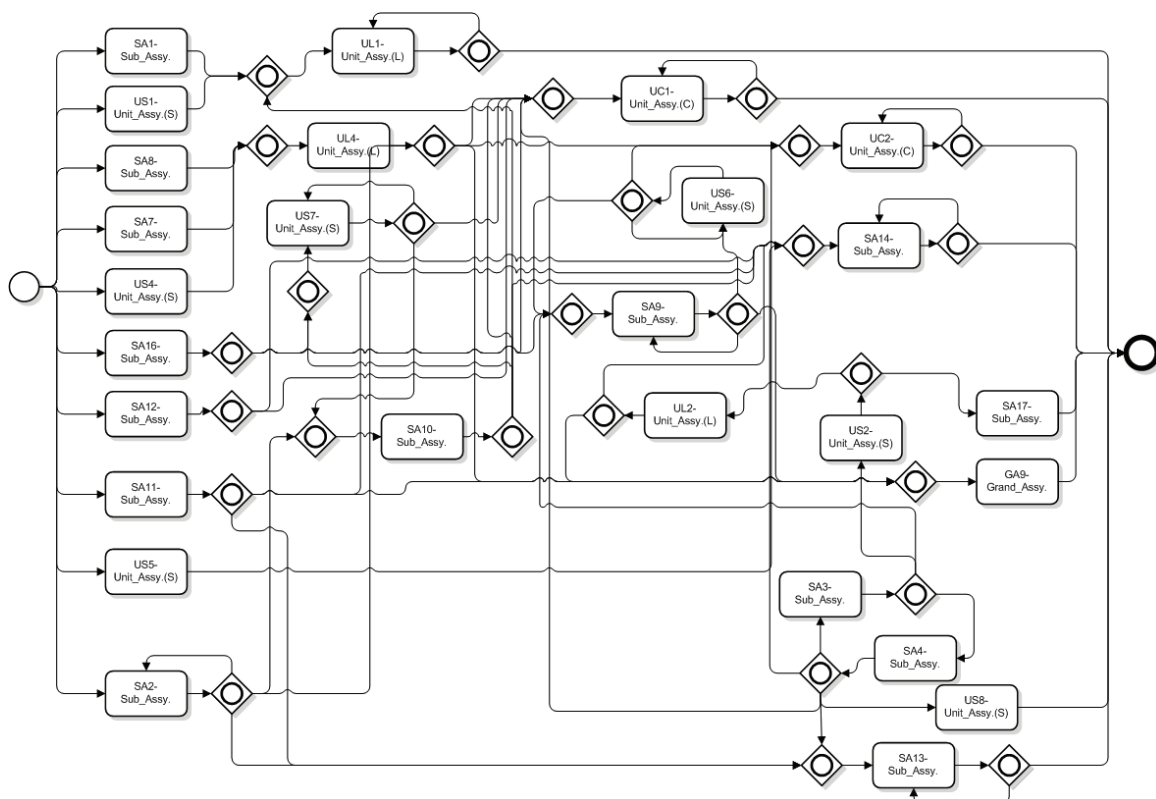
Figure 11: Block assembly process comprising 136 cases and 1706 events

CONCLUSION

Until now, process discovery algorithms have considered an event comprising different types of events as an activity, and thus have ignored the duration between those different types of events. Uniquely, this paper considers, for process-model-discovery purposes, events with *Start* and *Finish* event types as a single activity. A concept of "non-linear dependency" is used as the basic rule defining sequence relation between activities. Moreover, assuming non-linear dependency for each instance, more relations can be captured, and thereby, a discovered process model can be more effectively mimic the execution result of activity lifespan. Using a simple set operation to discover the process model, we developed a process model discovery algorithm. The results of a case study based on real-world block assembly data from a shipbuilding company show that the proposed methodology offers better activity representation in respect to execution duration (e.g., a parallel control flow). Going forward, the noise problem, the level of abstraction and, most importantly, fitness scoring, will be considered in our future work.

ACKNOWLEDGMENT

REFERENCES

1. Pinter, S.S., Golani, M. (2004), "Discovering workflow models from activities' life spans", *Computers in Industry*, Vol. 53, pp. 283-296.

2. Tsai, C.-H., Jen, H., Chen, Y.-C. (2010), "Time-interval process model discovery and validation-a genetic process mining approach", *Applied Intelligence*, Vol. 33, pp. 54-66.

3. Werf, J.M.v.d., Mans, R.S., Aalst, W.M.P.v.d. (2013), "Mining declarative models using time intervals", in Moldt, D. (Ed.), *34th International Conference on Application and Theory of Petri Nets and Concurrency Petri Nets 2013*, pp. 313-331.

4. Aalst, W.M.P.v.d. (2011), *Process mining: discovery, conformance and enhancement of business processes*. Springer, Heidelberg.

5. Winarko, E., Roddick, J.F. (2005), "Discovering richer temporal association rules from interval-based data", *LCNS*, Vol. 3589, pp. 315-325.

6. Aalst, W.M.P.v.d., Weijters, A.J.M.M., Maruster, L. (2004) "Workflow mining: discovering process models from event logs", *Knowledge and Data Engineering*, *IEEE Transaction on*, Vol. 16, pp. 1128-1142.

7. Weijters, A.J.M.M., Aalst, W.M.P.v.d., Medeiros, A.K. (2006) "Process mining with the heuristics miner algorithm", *Technology*, Vol. 166, pp. 1-34.

8. Medeiros, A.K.A.d., Dongen, B.F.v., Aalst, W.M.P.v.d., Weijters, A.J.M.M. (2004) "Process mining: extending the alpha-algorithm to mine short loops", working paper, BETA Working Paper Series 113, TU Eindhoven

9. Gunther, C.W., Aalst, W.M.P.v.d. (2007), "Fuzzy mining: adaptive process simplification based on multi-perspective metrics", *5th International Conference on Business Process Management*, pp. 328-343.

10. Aalst, W.M.P.v.d., Medeiros, A.K.A.d., Weijters, A.J.M.M. (2005) "Genetic process mining", *LCNS*, Vol. 3536, pp.48-69.

11. Wen, L., Wang, J., Aalst, W.M.P.v.d., Wang, Z., Sun J. (2009), "A novel approach for process mining based on event types", *Journal of Intelligent Information Systems*, Vol. 32, pp. 163-190.

12. Burattin, A., Sperduti, A. (2010), "Heuristics miner for time intervals", *European Symposium on Artificial Neural Networks – Computational Intelligence and Machine Learning (ESANN) 2010,* pp. 41-46.

13. Dijkman, R., La Rosa, M., Reijers, H.A. (2012), "Managing large collections of business process model-Current techniques and challenges", Editorial, *Computers in Industry*, Vol. 63, pp. 91-97.

14. Sun., S., Kumar, A., Yen, J. (2006), "Merging workflows: A new perspective on connecting business processes", *Decision Support Systems*, Vol. 42, pp. 844-858.

15. La Rosa, M., Dumas, M., Kaarik, R., Djikman, R. (2009), "Merging business process models (extended version)", working paper, Working papers 269, BETA Research School, Eindhoven, The Netherlands.

16. Van Dongen, B.F., van der Aalst, W.M.P., "Multi-phase process mining: Aggregating instance graphs into EPCs and Petri nets", *PNCWB 2005 Workshop*, pp. 35-58.

17. Nejati, S., Sabetzadeh, M., Chechik, M., Easterbrook, S., Zave, P. (2012) "Matching and merging of variant feature specifications", *Software Engineering, IEEE Transaction on*, Vol. 38, pp. 1355-1375.

18. Li, C., Reichert, M., Wombacher, A. (2008) "On measuring process model similarity based on high-level change operation", *LCNS*, Vol. 5231, pp. 248-264.

19. Rozinat, A., Aalst, W.M.P.v.d. (2008) "Conformance checking of processes based on monitoring real behavior", *Information Systems*, Vol. 33, pp. 64-95.

20. Buijs, J.C.A.M., Dongen, B.F.v., Aalst, W.M.P.v.d. (2012) "On the role of fitness, precision, generalization and simplicity in process discovery", *LCNS*, Vol. 7565, pp. 302-322.

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PROSPECTS OF DYNAMIC SCHEDULING CONCEPT IN CONSTRUCTION INDUSTRY

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ABSTRACT

Real-time events extremely disrupt the integrity of project schedules. The presence and implementation of a predefined Dynamic Scheduling strategy to mitigate these disruptions is a must for the successful implementation of projects planning. Despite of the wide practical applications of dynamic scheduling in various industries, especially manufacturing and computer engineering, there is a gap in the research for automated dynamic scheduling applications within the construction industry. An ongoing research in construction scheduling field is working on the development of a Dynamic Scheduling model for real-time cross-projects schedule analysis for construction enterprises. This paper will review the outcomes of the research investigation for the prospects of using the dynamic scheduling concepts in the construction industry.

Keywords: Dynamic Scheduling; Schedule Optimization; Construction Scheduling.

INTRODUCTION

Planning is the core of project management; so, its success contributes much to the success of projects. For the planning function to be successful, a complete and flexible resourced schedule must be generated before the project's commencement; and must be properly maintained during execution.

Construction projects are extremely dynamic, and maintaining schedules under various real-time events is a very hard task for the project management team; especially that almost all

current planning/scheduling practices are based on a static architecture. A construction oriented dynamic scheduling model is currently under development attempting to define a solution for dynamically handling real-time events with minimum disruption to construction schedules. This model will be used as the base for developing an automated dynamic scheduling optimization solution, which will be integrated with the commonly used project management practices, and to be validated with real construction projects data.

The main purpose of this paper was to investigate the need and suitability for the application of dynamic scheduling concepts in the construction industry. The literature in the context of dynamic scheduling in construction industry is minimal, and lacks the practical study and analysis of the problem, as well as the appropriateness of its possible solutions to construction industry. So, a questionnaire survey was designed and distributed to field practitioners to review and analyze the problem aspects, as well as to define the functional specifications of the proposed solution.

The paper will start with a brief review of the problem under study, and then the *Dynamic Scheduling* topic will be reviewed from a construction perspective. The prospects of using dynamic scheduling in construction industry will then be investigated vide a questionnaire survey. And finally, survey results will be summarized and analyzed with conclusions and suggestions on how implementation of dynamic scheduling can suit the construction industry.

PROBLEM OVERVIEW

The Dynamic Scheduling topic has gone through various researches and publications during the last two decades, especially within manufacturing and computer industries. However, it is still a quiet new topic in the application to construction industry; and there is a shortage in the literature of this topic in construction scheduling field.

Initially, a literature review was performed on static scheduling topic to outline the main features which govern static scheduling optimization process. *Herroelen et al [1998]* and *Brucker et al [1999]* collected and classified Resource Constrained Project Scheduling Problems (RCPSPs), which represent the core of static scheduling; they also proposed various optimization models for the problem's analysis. Another detailed survey was lately presented by *Hartmann and Briskorn [2010]* for variants and extensions of the RCPSP.

Project Scheduling, especially in the construction field, is inherently complex and dynamic, involving multiple feedback processes and nonlinear relationships. While problems encountered during construction are fundamentally dynamic, most researchers have been treating the problems statically within a partial view of a project *[Lyneis et al, 2001]*. As a result, schedule

delays and cost overruns are common in construction projects in spite of advances in construction equipment and management techniques. To overcome these chronic symptoms, enormous efforts have been devoted to the planning and control aspects of construction management *[Lee et al, 2006]*.

Methods and techniques of Dynamic Scheduling as well as real-time events which cause disruptions to static scheduling were discussed and categorized differently in several surveys and researches (*Suresh and Chaudhuri, 1993; Stoop & Wiers, 1996; Cowling & Johansson, 2002; Vieira et al, 2003; Ouelhadj & Petrovic, 2009*). These surveys, as well as the overall dynamic scheduling literature review performed under this study, showed that literature lacked studying practicality of dynamic scheduling implementation in construction. In addition, features and polices of any dynamic scheduling system in construction are subjective to project's conditions and management strategy. So, this study was introduced to cover the literature gaps related to prospects of implementing dynamic scheduling concepts in construction industry.

REAL-TIME EVENTS

From a construction industry point of view, real-time events can be classifies under three main categories:

- *Project related events:* Additions or omissions to the project's original scope (through change orders, or design changes), changes to the project's due dates or milestones, changes to the predefined sequence of works due to changes in priorities of the project's deliverables, delays in governmental or authorities approvals, effects of inclement weather, force majeure events (ex. floods or earthquakes), etc.
- *Resource related events:* Shortages of material, arrival of defective material/equipment, breakdowns of construction machinery on site, delayed arrivals of specialized resources, insufficient capacities of assigned resources, sickness or death of key resources, etc.
- *Operations related events:* Quality rejection of outputs, changes in deliverables specifications, prolongations in operations durations (due to incorrect estimates for resources productivities, incorrect estimates for equipment set-up times, or manpower learning curves), unexpected behaviour of predefined design elements (ex. unsatisfactory results of soil tests after the completion of ground improvement works), etc.

DYNAMIC SCHEDULING REVIEW FROM CONSTRUCTION INDUSTRY PERSPECTIVE

Dynamic Scheduling, as many other scheduling concepts, started and developed in the manufacturing industry; consequently, the majority of approaches, strategies and policies presented in the literature were mainly focusing on manufacturing systems and applications. The

approach followed in this section is to explain the concepts of dynamic scheduling as presented in the literature, with an orientation of the explanation, as much as possible, towards the construction industry perspective.

Dynamic scheduling categories

The effect of any of the above mentioned real-time events to the efficiency or even the correctness of a predefined schedule might be drastic; which, in some cases, might require a complete rescheduling of the project. Dynamic Scheduling defines the strategy of how to generate the original baseline and the strategy of how to respond to real-time events.

There are three main Dynamic Scheduling categories (or strategies) which have been listed in the reviews of *Aytug et al (2005)*, *Herroelen & Leus (2005),* and *Ouelhadj & Petrovic (2009)*:

a) Completely reactive scheduling

In this category, no baseline schedule is required, and real-time decisions are made locally, on the resource level, where the next activity to be executed by the resource is selected based on its priority (or predefined criteria) from the list of activities ready for execution. The benefits of this approach can be clearly acknowledged from the extremely low computational burden required for the analysis; in addition to the ease of explanation and understanding of its concepts and rules to the system users.
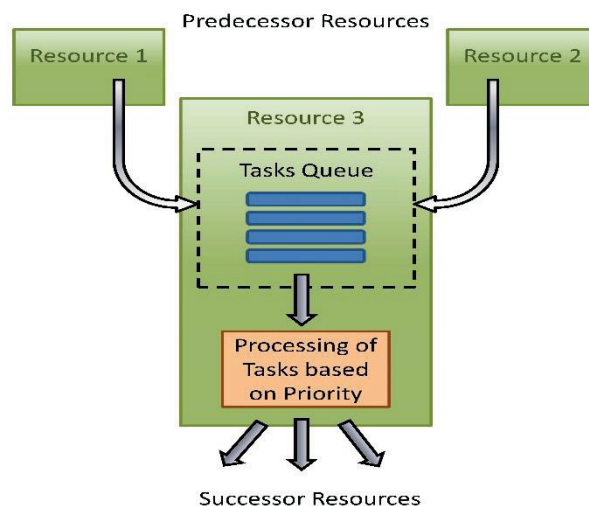
Figure 1: Completely Reactive Scheduling

This scheduling type is mainly used in manufacturing for on-spot scheduling of machine operations, and termed as *"Dispatching" [Bhaskaran and Pinedo, 1991]* or *"Priority Rule-based*

Scheduling" [Haupt, 1989]. Extension to this approach was introduced by *Wu and Wysk [1989]* allowing the system to select the dispatching rules dynamically based on the current system conditions (approach introduced).

Despite the fact that the concept of working without a schedule and prioritizing the work on a real-time basis is widely present in small construction companies and projects; however, the use of dispatching rules and a computerized system for the selection process, which is the core of this technique, is not used in the construction industry; concluding that the whole approach is not implemented in construction. In addition, the concept of not having a baseline schedule sounds like a disaster for moderate/high controlled construction projects.

b) Robust pro-active scheduling

This scheduling approach is based on building predictive schedules with studying the main causes of disruptions and integrating them into the schedules; which, predictably, can accommodate changes in a dynamic environment. The disruptions are measured based on actual completion measures compared to the originally planned completions; then the mitigation of these disruption are mitigated through simple adjustment to the activities durations. *Mehta & Uzsoy [1998, 1999]* and *Vieira et al [2000-a, 2000-b]* proposed various analytical models for predictive schedules preparation. This was followed by the development of a mathematical programming model by *Herroelen and Leus [2004]* for the generation of a stable project baseline schedule.
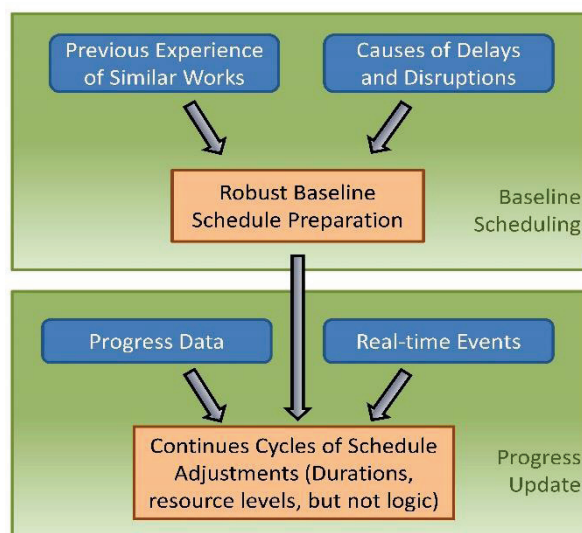
Figure 2: Robust Pro-active Scheduling

The conditions of this technique can be assumed to be similar to many cases in construction planning, where a baseline is produced, then updated periodically with actual progress figures and remaining durations, without adjustments to the original schedule logic. This case is common in traditional and regular construction projects, where the work sequence is clearly deterministic and the disruption probability is relatively low.

c) Predictive-reactive scheduling

The most common dynamic scheduling approach used in manufacturing systems *[Ouelhadj and Petrovic, 2009]*. The main concept of Predictive-reactive Scheduling is that a simple (or predictive) baseline schedule is initially generated, then rescheduled (logically revised) based on real-time events. The time, triggering event type and the magnitude of the schedule revision should be predefined in the system through a rescheduling policy and strategy (as explained in the next sections).
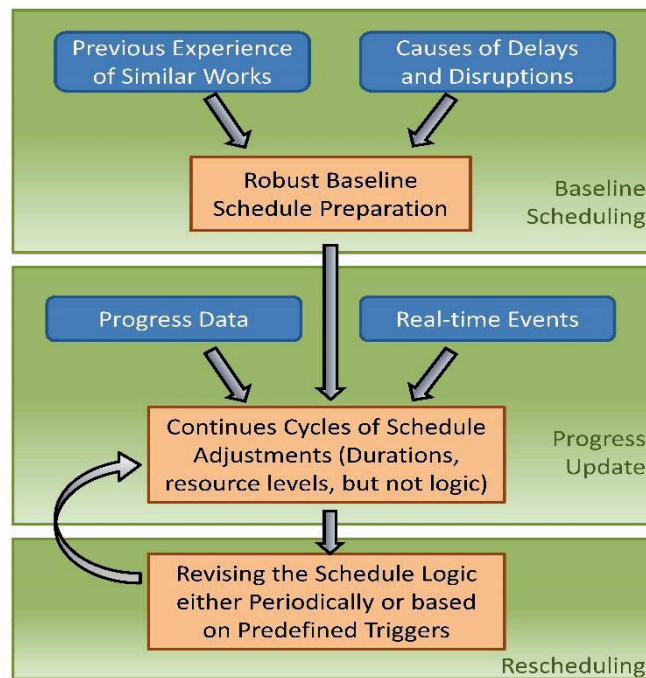
Figure 3: Predictive-Reactive Scheduling

Similarly to the case in manufacturing industry, the predictive-reactive scheduling is the most commonly used technique in construction industry. However, there are two major deficiencies which can be easily spotted in the implementation of this approach in construction. First, the preparation of a predictive (or robust) schedule is purely dependent on the planners' opinion and experience. Secondly, rescheduling process is always performed manually, and again its quality

depends on the planners' opinion and experience, which in many cases (especially large scale projects) will produce solutions far from the optimal solution, and in some cases the revised schedule will cause further disruptions to the project's earlier defined plans and strategies (resource levels, subcontractors time frames, material/equipment delivery dates …etc.). These deficiencies will be reviewed in detail later in this paper.

Since the predictive-reactive Scheduling is the most common and professional dynamic scheduling technique followed in construction, a further review was made to investigate the rescheduling policies, strategies and techniques; and the summary of this review is presented in the following sections.

Rescheduling policies

The rescheduling policy, in general terms, is an answer to the question of *when* to respond to real-time events. Three policies were presented in this context *(Church and Uzsoy, 1992; Sabuncuoglu and Bayiz, 2000; Vieira et al, 2000-a, 2003; Aytug et al, 2005)*:

- *Periodic rescheduling policy:* Where the rescheduling process is started every predefined time interval regardless of the amount of real-time events occurred during this period.
- *Event-driven rescheduling policy:* The scheduling process is triggered with the occurrence of any disruptive real-time event.
- *Hybrid rescheduling policy (Rolling time horizon): T*he rescheduling process takes place periodically regardless the in between events; however, certain predefined events can trigger the start of a new intermediate rescheduling process.

In construction industry, scheduling/rescheduling processes are performed in a periodical basis, grouping all events which occurred in between. Accordingly, the *Periodic rescheduling policy* is the most suitable policy for the construction industry, because it covers the main requirements of construction real-time environment: rescheduling when major events occur (as defined by the system users), and periodical minor rescheduling which is usually required to optimize the resources usage based on the current project status. This statement will be further investigated in the construction practitioners survey presented later in this paper.

Rescheduling strategies

The *rescheduling strategy* & the re*scheduling techniques* represent the answer to the question of *how* to respond to real-time events. The *rescheduling strategy* is concerned about the mass of the changes to be made, while the *rescheduling technique* is concerned about the method or the approach to be followed to revise the schedule. Two main strategies were presented in this context *(Sabuncuoglu and Bayiz, 2000; Cowling and Johansson, 2002; Vieira et al, 2003)*:

Proceedings of 2014 International Conference on
Technology Innovation and Industrial Management
28th-30th May 2014, Seoul, South Korea

- *Schedule repair:* The schedule repair is the process of mitigating the real-time event through minimum adjustments to the schedule portion related to the event. The major benefit of this strategy is the saving of computational burden.
- *Complete rescheduling:* Is the process of regenerating the project schedule from scratch. This strategy is practically not preferred due to the required computational time and effort, despite of the fact that it helps in maintaining the near-optimum solution.

For construction industry, both strategies should be implemented depending on the type and magnitude of the corresponding real-time event, and also depending on the allowable changes from a contractual perspective.

Rescheduling techniques

The rescheduling technique represents the methodology or algorithm which a computerized system will use to repair/reschedule the project plan. The following techniques were presented in the context of dynamic scheduling:

- *Heuristic techniques:* A heuristic is a technique that seeks good solutions at a reasonable computational cost without being able to guarantee either feasibility or optimality, or even in many cases to state how close to optimality a particular feasible solution is *[Reeves, 1995]*. The most common, but not efficient, schedule repair method is the *Right-shift schedule repair*, where the process of updating the status of progressed activities, and shifting the remaining works forward in time based on their schedule logic. This is the regular update process used in construction, and almost all software packages available in the market use this repair method as a part of the CPM concepts. Other heuristic methods includes: *Match-up schedule repair* (a recovery schedule is prepared in order to match original at some point in time)*, Partial schedule repair* (only the impacted schedule portion is rescheduled), and *Dispatching rules* (decisions are made locally at the resource level without working with a main schedule).
- *Meta-heuristic techniques:* These are high level heuristics which guide local search heuristics to escape from local optima. Meta-heuristics commonly used in schedule repair/rescheduling are: *tabu search (Mehta and Uzsoy, 1999)*, *simulated annealing (Zweben and Fox, 1994)*, *genetic algorithms (Rossi and Dini, 2000; Chryssolouris and Subramaniam, 2001)*, and *Ant Colony (Xianga and Lee, 2008).*
- *Other Artificial Intelligence Techniques:* Dynamic scheduling is an ideal problem for studies in the AI field. Various researches adopted the problem and presented different AI approaches for its solution; these studies used *Knowledge Based Systems (Fox, 1994; Park et al, 1996; Le Pape, 1994; Henning & Cerda, 2000)*, *Case-based Reasoning (Miyashita & Sycara, 1995)*, *Neural Networks (Suresh & Chaudhuri, 1993; Meziane et al, 2000)*, *Fuzzy*

Logic (Schmidt, 1994; Petrovic & Duenas, 2006), and hybrid systems between different AI techniques *(Jahangirian & Conroy, 2000; Li et al, 2000)*.

Dynamic scheduling architectures

a) Single-agent Dynamic Scheduling

In most common planning and scheduling systems, the analysis process is done via centralized agent (central computer or database server), in order to ensure consistency of data and results. The centralized approach of the single-agent dynamic scheduling architecture can be claimed to create bottle-necks in the system work flow, and it consists of a single point of decision making which, if failed, causes the failure of the whole system.
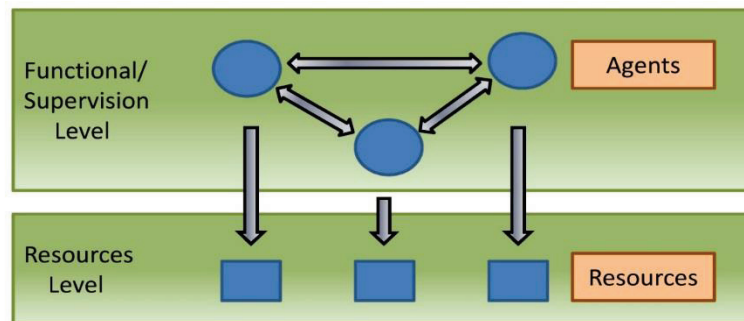
Figure 4: Autonomous Dynamic Scheduling

b) Multi-agent Dynamic Scheduling

The multi-agent based technique proposes the introduction of several local decision points (or schedule analysis points) within the functional/supervision level, in order to deal with the analysis of local real-time events and perform local schedule repairs.
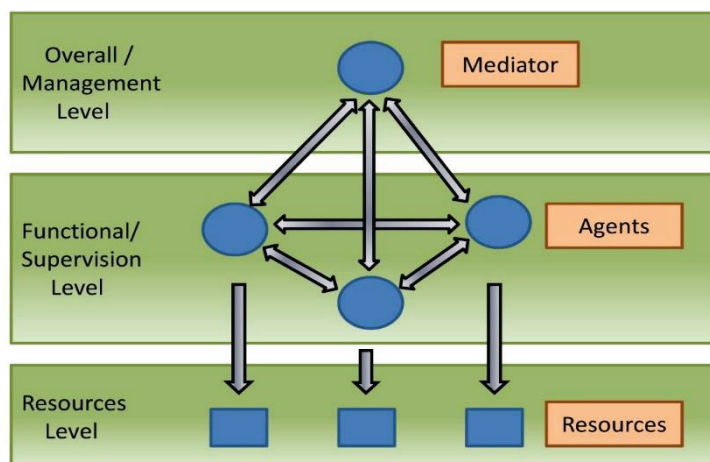
Figure 5: Mediator Dynamic Scheduling

Two main architectures were presented for multi-agent based system: Autonomous architecture (Figure 3.4) and Mediator architecture (Figure 3.5). *Parunak [1987]* presented the concept of autonomous architecture, where local agents are completely responsible for generating and maintenance of their own schedules, and they cooperate directly with each other to generate optimal overall schedule for the entity (or project). This architecture is very effective in optimizing the analysis and decision time; however, it has one main drawback in the relative failure of local agents to produce near optimal solution for the entity. This drawback was addressed in mediator architecture (originally proposed by *Ramos [1994]*), where a mediator agent is introduced to support in the communication process between local agents for improving the efficiency of the overall schedule, which will also show further improvement with the increase in the application size.

In manufacturing/other industries, which adopted dynamic scheduling in their applications (as shown in next section), *Mediator/Agents/Resources* are all computer based entities, where conditions are analyzed and decisions are made automatically.

In construction industry, the *Mediator* architecture is the common practice for the ongoing planning process; however, it is implemented in a non-automated environment, and the project planner takes the responsibility of presenting the different alternatives with its advantages/ disadvantages to management level, and then manually incorporates the decisions made into the project's schedule. In a non-automated environment, this process becomes purely dependent on the capabilities of the planner to capture the different alternatives for all functional levels (*agents*) and to properly present it to management to support decision making; which might make the outputs of the overall process far beyond the optimum/near-optimum solution.

Dynamic scheduling applications

The dynamic scheduling concepts are widely used worldwide in various non-construction industries. The followings are selected examples of dynamic scheduling applications in several non-construction industries: *Lagodimos et al [2004]* in manufacturing industry, *Webster and Azizoglu [2001]* in computer engineering, *Liang [2009]* in logistics industry, *Warburg et al [2008]* in aviation industry, and *Aissani et al [2009]* in petroleum industry. Despite of the wide practical applications of dynamic scheduling in many industries, the review performed was not able to locate automated dynamic scheduling applications within the construction industry, only few researches were found presenting frameworks for Dynamic Planning (such as *Lee et al, 2006*), and few resource allocation field practices especially in the maintenance and service based companies. And accordingly this study will review the suitability of dynamic scheduling to the nature of construction industry.

PROSPECTS OF DYNAMIC SCHEDULING IN CONSTRUCTION

In previous section, the dynamic scheduling's elements were reviewed with a theoretical orientation of what and how these elements can be implemented in the construction industry. However, to be able to conclude that dynamic scheduling concepts can be used in construction industry, a questionnaire survey was designed and distributed on construction project management practitioners. The survey reviewed the scheduling/rescheduling problem from practical construction point of view, and reviewed the suitability and practicality of a dynamic scheduling solution to the practical day-to-day scheduling works.

5.1. Questionnaire Survey Design

- *Objective:* The main objective of the questionnaire was to gather the experienced opinion of field practitioners about the main problems they face with respect to schedules optimization and rescheduling processes, and the practicality measures of implementing a dynamic scheduling system in construction industry. The survey also reviewed the expectations of what functions/features to be present in any proposed dynamic scheduling solution. This main objective was divided into few sub-objectives as explained briefly in the following sections details.

Table 1: General info on Survey Responses

Total Questionnaire Participants:	364
Participants Nationalities:	52
No. of Countries where Participants worked:	131
Total Number of Invitations:	1,347
Response Rate:	27%

- *Population:* The topic to be surveyed is pure a construction scheduling related; so, the population for the survey was the construction planners/schedulers with their different level of experience.
- *Sample Design:* The planning/scheduling process is now having some sort of common practice concepts due to the presence of commonly accepted knowledge guidelines and due to the use of common software packages which share the same concepts of modeling, inputs, analysis and outputs.

  So, the sample to be chosen for the survey was not intended to be large in size or to be spread over large number of different practices; it just needed to represent different types of directly involved practitioners (contractors/consultants planners), different expertise levels (senior/junior planners and management) which will identify different levels of requirements,

as well as planners with different nationalities & with different working locations in order to have a broad opinion about the expected features of the proposed solution.

Survey sample distribution and demographic analysis

A webpage was developed for the questionnaire survey and published on the internet to facilitate its spreading. Then invitations were sent to major construction companies and consultancy offices; in addition, other invitations were sent to the members of few popular planning/project management forums.
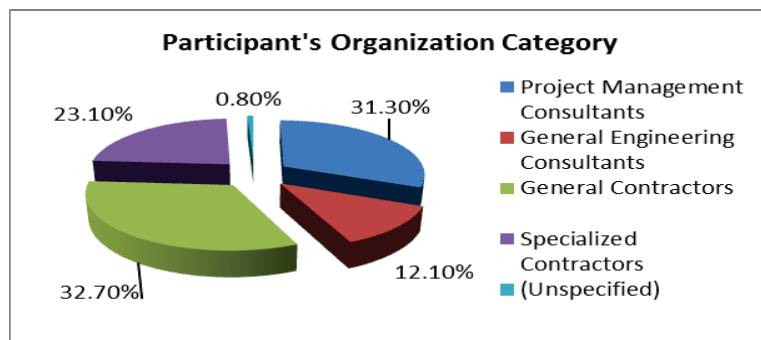
Figure 6: Responses distribution on Organization

The total number of invitations was 1347 (after deducting inactive forum members), and the total number of participants was 364, with a response rate of about 27%. Table 1 shows the summary statistics of the received responses.
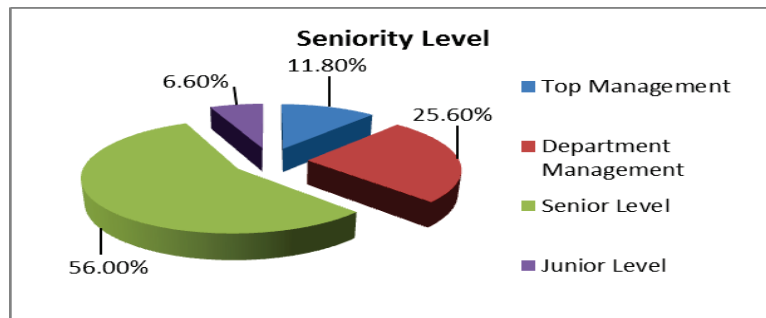
Figure 7: Responses distribution on Organizational
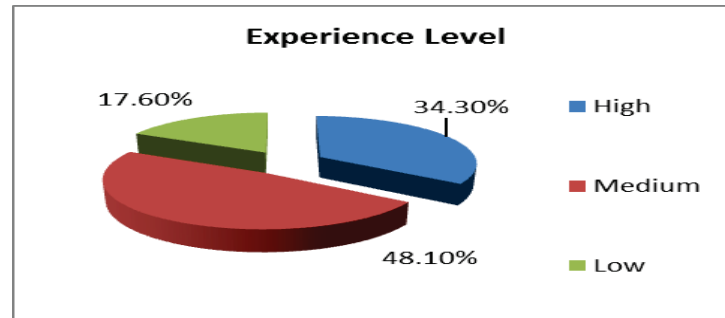
Figure 8: Responses distribution on Experience Level

The participants were fairly distributed among different organization categories as shown in Figure 1. Their distribution was also ideal with respect to seniority and experience levels (figures 2 & 3), where all roles/experience levels were required to participate, especially Senior Level and high/medium experience planners because they will be the main target users for any proposed technical solution.

Statistical methods used

A combination of frequency distribution and descriptive statistics were used for the analysis of survey responses as will be shown later in the *Discussion* section.

RESULTS ANALYSIS AND DISCUSSION

Reliability and validity of responses

With respect to geographical distribution, the following table shows that the participants were well distributed all over the world. The distribution was even close to the worldwide population distribution as per the UN population reports [UN Pop. Report 2011] (as shown in table no. 2), except for Asia & Europe; this is reasonable because the higher the countries' prosperity, the higher the need for project management and planning. So, in light of the above, the results can be claimed to represent the worldwide planning population.

Table 2: Comparison of Responses distribution by Location and the world's population distribution on 2010 (UN Pop. report 2011)

Survey Participants			2010 Population		Variance
Location	*No.*	*%*	**Millions**	**%**	
Africa	58	15.9%	1,033	14.9%	1.0%
Asia	124	34.1%	4,167	60.3%	-26.2%
Europe	114	32.1%	733	10.6%	21.5%
North America	33	9.1%	352	5.1%	4.0%
South America	11	3.0%	589	8.5%	-5.5%
Oceania	21	5.8%	36	0.5%	5.2%
TOTAL	345	100.0%	6,910	100.0%	

With respect to validity of responses, the survey was designed to include within few questions certain answers which are logically not applicable regardless of the role and experience of the participant (for example: 'Disruption to schedules never happed' or 'Real-Time events does not impact schedules' … etc.). The results showed that the frequency of selection for these answers were always less than 1% of the responses, which gives good credibility to the balance results. In addition, the results for the future communications section of the survey show that there was a general interest from participants in the subject under study, where more than 92% of the participants were interested to receive the final results of the survey, and nearly 96% were interested to receive further research updates for the same subject; this interest in the subject can be considered as another sign to the seriousness (i.e. validity) of the responses.

The following sections points will review the review and analyze the participants responses with respect to the main issues surveyed in the questionnaire:

The need for dynamic scheduling in construction projects

As mentioned earlier, the Rescheduling Problem section was intended to collect the participants' opinions about scheduling/rescheduling problems. With respect to resources analysis, 97.8% selected that it is required to be performed before baseline schedule submission, from which 87.5% acknowledged that the time was always not sufficient to review all resources distribution. For cash flow analysis, 91.4% selected that it is required, while 75.8% acknowledged that the time was always not sufficient to change the schedule accordingly. Similar response ratios were given to the same issues during schedule updates, but with less importance to cash flow analysis where 16.8% selected that it is not required during schedule updates.

Real time events were selected as the main cause of disruption to schedules, where less than 0.8% of the participants stated the real-time events does not impact schedule integrity, while more than 85% selected that this disruption usually/always happens.

Finally, 96.4% selected that the presence of optimization software might help during baseline scheduling, from which 70% selected that such software will definitely have an added value. A similar response ratio was given to the importance of this optimization software tool during schedule updates.

Suitability of Dynamic Scheduling to construction projects

In light of the above, the need for a dynamic scheduling solution is highly recognized by the planning community. However, this cannot be used to claim the suitability of such a system to construction projects, especially when taking into consideration contractual aspects. The means for measuring the suitability of dynamic scheduling to construction projects was to survey the practicality of *how* and *when* optimization cycles can be accepted within running projects.

First, for Frequency of Optimization (or When?), table 3 shows the responses to the question investigating how frequent there is a need for dynamically proposing optimized schedule alternatives. 'Along with periodical updates' was the most preferred choice for survey participants (45.6%), while the balance of responses was distributed on the other three choices. The response distribution was almost the same when responses were categorized according to organization type and experience level.

Table 3: Summary of Responses to 'Frequency of Optimization'

Questions / Response Alternatives		Total Responses		Responses Categorization						
				By Organization Type				By Experience Level		
		No.	%	PM Cons.	Eng. Cons.	Gen. Contr.	Spec. Contr.	High	Med.	Low
Frequency of proposing optimized alternatives										
1	Along with each periodical update	160	45.6%	44.1%	46.5%	46.5%	46.9%	44.4%	47.0%	44.1%
2	Crossing resource thresholds	41	11.7%	11.7%	9.3%	12.3%	11.1%	7.3%	14.3%	13.6%
3	Delay in a predefined milestone	59	16.8%	18.0%	14.0%	12.3%	23.5%	20.2%	14.3%	16.9%
4	Only when requested by planner	91	25.9%	26.1%	30.2%	28.9%	18.5%	28.2%	24.4%	25.4%
	TOTAL	351	100%	31.6%	12.3%	32.5%	23.1%	35.3%	47.9%	16.8%

While for the mass of changes acceptable, table 4 shows that a considerable percentage of the respondents (40.2%) selected that large changes can be accepted at any time depending on the

benefits of these changes; but also this ratio was a bit less to experienced planners when responses were further categorized. High experienced participants as well as consultants less preferred this choice but still in average it is the most selected, this is mainly because large experienced planners will know that majorly changed schedules are not that easy to pass frequently to project team to execute, even if the benefit of change is high.

Table 4: Summary of Responses to 'Frequency of Large Changes'

Questions / Response Alternatives		Total Responses		Responses Categorization						
				By Organization Type				By Experience Level		
		No.	%	PM Cons.	Eng. Cons.	Gen. Contr.	Spec. Contr.	High	Med.	Low
Frequency of large changes										
1	Depends of the output benefits	142	40.2%	39.1%	32.6%	43.5%	42.2%	36.3%	42.6%	41.7%
2	Along with periodical updates	22	6.2%	4.5%	7.0%	7.0%	7.2%	6.5%	7.1%	3.3%
3	Separate What-If schedules	93	26.3%	31.8%	18.6%	22.6%	27.7%	29.0%	26.0%	21.7%
4	Along with schedule revision	96	27.2%	24.5%	41.9%	27.0%	22.9%	28.2%	24.3%	33.3%
	TOTAL	353	100%	31.2%	12.2%	32.6%	23.5%	35.1%	47.9%	17.0%

Most other responses discarded the choice that large changes can be made along with periodical update, and accepted to have such changes either with schedule revisions or as separate What-If schedules.

Based on the above responses, the practicality for using a dynamic scheduling system in construction project is not questionable; however, the practicality can be bounded by how and when schedule changes (optimization outputs) are allowed based on the project conditions.

Prioritize parts of the schedule to be optimized

Optimization of medium and large scale schedules involves large computational burden, and the number of activities/resources to be optimized is exponentially proportional to the optimization time. This was explained to the survey participants and their feedbacks were collected on how to minimize the number of activities/resources to be optimized without affecting the purpose of the optimization process. More than 50% of participants responded that the optimization algorithm can concentrate on critical/near critical activities leading to project milestones; while for the rest of responses (as shown in Table 5) is more oriented towards optimizing all activities rather than critical activities only. This can be modeled in any proposed solution to be optional based on the requirements of each project.

Table 5: Summary of Responses to 'Mass of Optimization'

Questions / Response Alternatives		Total Responses		Responses Categorization						
				By Organization Type				By Experience Level		
		No.	%	PM Cons.	Eng. Cons.	Gen. Contr.	Spec. Contr.	High	Med.	Low
Portions of the schedule to be analyzed for optimization										
1	Critical activities for completion	29	8.4%	8.5%	4.7%	7.0%	12.3%	6.5%	9.6%	8.8%
2	Critical/near critical activities leading to milestones	176	50.7%	51.9%	46.5%	55.7%	45.7%	53.2%	48.8%	50.9%
3	Critical/near critical activities & close to data date	59	17.0%	16.0%	20.9%	15.7%	17.3%	14.5%	19.9%	14.0%
4	All activities	83	23.9%	23.6%	27.9%	21.7%	24.7%	25.8%	21.7%	26.3%
	TOTAL	347	100%	30.5%	12.4%	33.1%	23.3%	35.7%	47.8%	16.4%

Practicality of different optimization objectives

For any optimization process one or more objectives must be predefined, and then the optimization algorithm will try to find the best possible value for the main objective, or optimize the value of an objective function combining the group of objectives based on predefined weights between them.

The classical objective for scheduling problems is optimizing the schedule completion time (minimum project duration and/or earlier milestone dates); other objectives can also be used like resources leveling, minimizing overall cost, minimizing negative cash flow, improving schedule indices, etc.

For using cost and cash flow within optimization objectives, more than 83% of the responses suggested that cost should be used, but there was no common agreement on how it should be used. This can be analyzed that almost all participants are confident that cost aspects are very important to be considered; but due to different practices used to analyze and monitor cost and cash flow, there was no agreement on how these can be integrated in the optimization objectives. And accordingly, cost and cash flow should be considered as optional objectives, but never to be ignored.

Similarly, table 6 shows that there was common agreement that different schedule indices should be used as part of the optimization objectives; but because these measures are not widely used in practical life, there was no agreement on which ones to be used. And again, these objectives should be considered as optional, and their weight within other optimization objectives to be purely dependent on how such indices can serve the project overall objectives.

Table 6: Summary of Responses to 'Practicality of different optimization objectives'

Questions / Response Alternatives		Total Responses		Responses Categorization						
				By Organization Type				By Experience Level		
		No.	%	PM Cons.	Eng. Cons.	Gen. Contr.	Spec. Contr.	High	Med.	Low
Using cost as one of the optimization objectives										
1	Monitoring costs on cost codes level	180	31.0%	34.4%	27.9%	28.8%	31.9%	32.7%	30.6%	29.0%
2	Monitoring the project's total cost	125	21.6%	20.8%	17.6%	23.0%	22.2%	17.1%	25.3%	20.0%
3	Monitoring project's cash flow	179	30.9%	30.1%	30.9%	32.5%	29.6%	29.1%	30.2%	36.0%
4	Loading costs to schedule is not practical	96	16.6%	14.8%	23.5%	15.7%	16.3%	21.1%	13.9%	15.0%
	TOTAL	580	100%	31.2%	12.2%	32.6%	23.5%	35.1%	47.9%	17.0%
Using schedule indices in the optimization objectives										
1	Criticality Index	192	27.6%	26.5%	23.8%	28.9%	29.0%	28.2%	27.7%	26.0%
2	Float Index	145	20.9%	20.5%	19.0%	22.4%	20.4%	18.1%	22.1%	23.0%
3	Activities Flexibility Index	172	24.7%	25.6%	27.4%	20.3%	28.4%	27.7%	23.8%	21.0%
4	Resources Flexibility Index	186	26.8%	27.4%	29.8%	28.4%	22.2%	26.1%	26.3%	30.0%
	TOTAL	695	100%	31.3%	12.1%	33.2%	22.8%	34.4%	48.5%	17.2%

Schedule considerations in the process of dynamic schedules optimization

There are some main considerations which should be defined prior to developing the core of the optimization solution: whether or not to use Activity Modes, cross-project resource allocation, and what optimization tactic to be adopted by the optimization algorithm.

As shown in table 10, opinions for activity modes was not oriented to a clear choice, but there was a larger response rate towards implementing activity mode to critical resources (i.e. critical activities driven by resources). And accordingly, activity modes must be considered in the mathematical modeling for construction schedules; and whether or not to use modes should depend on what execution modes users will define in their schedules.

With respect to cross-projects resource allocation, more than 67% accepted this concept, where more than half of this ration constrained this with the consideration of mobilization and demobilization cycles. Most of the participants did not accept that resource allocation between projects should be constrained to tool and/or manpower; so, equipment resources should also be considered.

And finally, for optimization tactics, the responses were evenly distributed among the four given choices; which means that none of the given tactics was felt by the participants to be the most suitable choice, so all of them can be used separately or combined depending on the optimization process requirement.

Table 7: Summary of Responses to 'Schedule Considerations'

Questions / Response Alternatives		Total Responses		Responses Categorization						
				By Organization Type				By Experience Level		
		No.	%	PM Cons.	Eng. Cons.	Gen. Contr.	Spec. Contr.	High	Med.	Low
Practicality of using activity modes										
1	Must be used for all resources	86	25.0%	27.8%	14.3%	29.7%	21.0%	24.2%	26.9%	21.1%
2	To be used only for critical resources	121	35.2%	31.5%	33.3%	36.9%	38.3%	34.2%	35.9%	35.1%
3	Along with major schedule revision	76	22.1%	20.4%	33.3%	18.9%	23.5%	20.8%	21.6%	26.3%
4	Activity modes are not practical	61	17.7%	20.4%	19.0%	14.4%	17.3%	20.8%	15.6%	17.5%
	TOTAL	347	100%	30.5%	12.4%	33.1%	23.3%	35.7%	47.8%	16.4%
Practicality of using resource allocation between projects as an optimization option										
1	Yes if there is benefit from allocation	102	30.3%	32.7%	22.5%	33.6%	25.9%	28.8%	34.0%	22.8%
2	Yes with considering mobilization /demobilization Cycles	124	36.8%	31.8%	47.5%	34.6%	42.0%	33.9%	38.3%	38.6%
3	Yes for tools/manpower, but not for equipment	25	7.4%	9.3%	5.0%	6.5%	7.4%	5.1%	9.3%	7.0%
4	Not a practical option	86	25.5%	26.2%	25.0%	25.2%	24.7%	32.2%	18.5%	31.6%
	TOTAL	337	100%	31.8%	11.9%	31.8%	24.0%	35.0%	48.1%	16.9%
Optimization tactics										
1	Resource levels adjustment	145	22.4%	22.0%	16.9%	26.6%	19.7%	21.8%	23.0%	21.9%
2	Re-sequencing similar activities	179	27.7%	25.5%	27.7%	29.0%	28.6%	25.6%	28.7%	29.2%
3	Lags manipulation	149	23.0%	26.0%	24.1%	21.5%	21.1%	23.9%	21.8%	25.0%
4	Tactic selection depends on optimization objectives	174	26.9%	26.5%	31.3%	22.9%	30.6%	28.6%	26.5%	24.0%
	TOTAL	647	100%	31.3%	13.0%	31.6%	23.6%	35.1%	47.5%	17.4%

Integration of the Dynamic Scheduling solution with project management practices

One of the final targets of this research is to produce a dynamic scheduling solution practically compliant with the existing planning and scheduling practices worldwide. This objective cannot be achieved without integrating the tool with the existing software packages.

The following table shows that more than 50% of responses preferred a fully integrated solution. Also the preference was higher for more experienced participants, which can be claimed as a further justification for the need for dynamic scheduling system.

Table 12: Summary of Responses to Question 28

	Questions / Response Alternatives	Total Responses		Responses Categorization						
				By Organization Type				By Experience Level		
		No.	%	PM Cons.	Eng. Cons.	Gen. Contr.	Spec. Contr.	High	Med.	Low
How the new software should be integrated with current project management practices?										
1	Completely dependent software	20	5.9%	9.4%	2.3%	4.7%	5.0%	3.4%	9.3%	1.7%
2	Dependent for all planning features, with conversion ability to other file formats	57	16.8%	14.2%	20.5%	16.8%	18.8%	10.1%	18.6%	25.4%
3	Dependent for optimization only & communicate through well-known file formats	77	22.7%	19.8%	25.0%	26.2%	21.3%	21.8%	23.0%	23.7%
4	Completely Integrated	185	54.6%	56.6%	52.3%	52.3%	55.0%	64.7%	49.1%	49.2%
	TOTAL	339	100%	31.3%	13.0%	31.6%	23.6%	35.1%	47.5%	17.4%

CONCLUSION

The problem of scheduling in the presence of real-time events is of great importance for the successful implementation of scheduling systems in construction projects. Various researches should be generated in construction scheduling field to investigate the issue of how to handle the occurrence of real-time events during the execution of a given schedule, in regard of how and when to run the repair or the optimization algorithms to the current static schedule to bring it back to the optimal or near- optimal state.

This paper performed a construction industry oriented review for the dynamic scheduling elements and their suitability to implementation in construction. The prospects of developing a dynamic scheduling solution in construction was further investigated through a questionnaire survey distributed on the project management practitioners within the construction industry. The results of the survey were used to identify the practical features of any solution which can be used for real-time scheduling in construction enterprises.

The statistical analysis of survey responses showed that most of the participants acknowledged the need for an optimization tool to support them during planning/scheduling their projects. The analysis also showed a clear interest of the project management population to the

new subject. The prospects in this paper will be used to define a model for application of dynamic scheduling in construction industry. The new model & its application will be developed, validated and verified, and the findings will be reported in future papers.

REFERENCES

1   Aissani, N., B. Beldjilali, B., & Trentesaux, D., (2009). *"Dynamic scheduling of maintenance tasks in the petroleum industry: A reinforcement approach"*, Engineering Applications of Artificial Intelligence 22(7), 1089-1103.

2   Aytug, H., Lawley, M.A., McKay, K.,Mohan, S. & Uzsoy, R., (2005). *"Executing production schedules in the face of uncertainties: A review and some future directions"*, European Journal of Operational Research 161(1), 86–110.

3   Bhaskaran, K., & Pinedo, M., (1991). *"Handbook of Industrial Engineering"*, John Wiley, New York.

4   Brucker, P., Drexl, A., Mohring, R., Neumann, K., & Pesch, E., (1999). *"Resource-constrained project scheduling: Notation, classification, models, and methods"*, European Journal of Operational Research 112(1), 3-41.

5   Chryssolouris, G., & Subramaniam, V., (2001). *"Dynamic scheduling of manufacturing job shops using genetic algorithms"*, Journal of Intelligent Manufacturing 12(3), 281-293.

6   Church, L., & Uzsoy, R., (1992). *"Analysis of periodic and event-driven rescheduling policies in dynamic shops"*, International Journal of Computer Integrated Manufacturing 5, 153-163.

7   Cowling, P., & Johansson, M., (2002). *"Using real time information for effective dynamic scheduling"*, European Journal of Operational Research 139(2), 230-244.

8   Fox, M., (1994). *"ISIS: A retrospective. Intelligent scheduling"*, Intelligent scheduling, 1-28.

9   Hartmann, S., & Briskorn, D., (2010). *"A survey of variants and extensions of the resource-constrained project scheduling problem"*, European Journal of Operational Research 207(1), 1-14.

10 Haupt, R., (1989). *"A survey of priority rule-based scheduling"*, OR Spektrum 11, 3-16.

11 Henning, G. P., & Cerda, J., (2000). *"Knowledge-based predictive and reactive scheduling in industrial environments"*, Computers and Chemical Engineering 24(9), 2315-2338.

12 *a survey of recent developments"*, Computers and Operations Research 25(4), 279-302.

13 Herroelen, W., & Leus, R., (2004). *"The construction of stable project baseline schedules"*, European Journal of Operational Research 156(3), 550-565.

14 Herroelen, W., & Leus, R., (2005). *"Project scheduling under uncertainty: Survey and research potentials"*, European Journal of Operational Research 165(2), 289-306.

15 Herroelen, W., Reyck B.D., & Demeulemeester E., (1998). *"Resource-constrained project scheduling:* Jahangirian, M., & Conroy, G. V., (2000). *"Intelligent dynamic scheduling system: the application of genetic algorithms"*, Integrated Manufacturing Systems 11(4), 247-257.

16 Lagodimos, A., Mihiotis, A., & Kosmidis, V., (2004). *"Scheduling a multi-stage fabrication shop for efficient subsequent assembly operations"*, International Journal of Production Economics 90(3), 345-359.

17 Lee, S. H., Mora, F. P., & Park, M. (2006). *"Dynamic planning and control methodology for strategic and operational construction project management"*, Automation in Construction 15(1), 84-97.

18 Le Pape, C., (1994). *"Scheduling as intelligent control of decision making and constraint propagation"*, Intelligent scheduling, 67-98.

19 Liang, C., Huang, Y., & Yang, Y., (2009). *"A quay crane dynamic scheduling problem by hybrid evolutionary algorithm for berth allocation planning"*, Computers & Industrial Engineering 56(3), 1021-1028.

20 Li, H., Li, Z., Li, L. X., & Hu, B., (2000). *"A production rescheduling expert simulation system"*, European Journal of Operational Research 124(2), 283-293.

21 Lyneis, J., Cooper, K., & Els, S., (2001). *"Strategic management of complex projects: a case study using system dynamics"*, System Dynamics Review 17(3), 237-260.

22 Mehta, S.V., & Uzsoy, R., (1998). *"Predictable scheduling of a job shop subject to breakdowns"*, IEEE Transactions on Robotics and Automation 14, 365-378.

23 Mehta, S.V., & Uzsoy, R., (1999). *"Predictable scheduling of a single machine subject to breakdowns"*. International Journal of Computer Integrated Manufacturing 12(1), 15–38.

24 Meziane, F., Vadera, S., Kobbacy, K., & Proudlove, N., (2000). *"Intelligent systems in manufacturing: current developments and future prospects"*, Integrated Manufacturing Systems 11(4), 218-238.

25 Miyashita, K., & Sycara, K., (1995). *"CABINS: a framework of knowledge acquisition and iterative revision for schedule improvement and reactive repair"*, Artificial Intelligence 76(1), 377-426.

26 Ouelhadj, D., & Petrovic, S., (2009). *"A survey of dynamic scheduling in manufacturing systems"*, Journal of Scheduling 12, 417-431.

27 Park, J., Kang, M., & Lee, K., (1996). *"Intelligent operations scheduling system in a job shop"*, International Journal of Advanced Manufacturing Technology 11, 111-119.

28 Parunak, H., (1987). *"Manufacturing experience with the contract net"*, Distributed artificial intelligence, 28-310.

29 Petrovic, D., & Duenas, A., (2006). *"A fuzzy logic based production scheduling/rescheduling in the presence of uncertain disruptions"*, Fuzzy Sets and Systems 157(16), 2273-2285.

30 Ramos, C., (1994). *"An architecture and a negotiation protocol for the dynamic scheduling of manufacturing systems"*, Proceedings of IEEE international conference on robotics and automation, 8-13.

31 Reeves, C. R. (1995). *"Modern heuristic techniques for combinatorial problems"*, John Wiley & Sons, McGraw-Hill International Limited, UK.

32 Rossi, A., & Dini, G., (2000). *"Dynamic scheduling of FMS using a real-time genetic algorithm"*, International Journal of Production Research 38(1), 1-20.

33 Sabuncuoglu, I., & Bayiz, M., (2000). *"Analysis of reactive scheduling problems in a job shop environment"*, European Journal of Operational Research 126(3), 567–586.

34 Schmidt, G., (1994). *"How to apply fuzzy logic to reactive scheduling"*, Knowledge-based reactive scheduling, 57-67.

35 Stoop, P., & Wiers, V., (1996). *"The complexity of scheduling in practice"*, International Journal of Operations & Production Management 16(10), 37-53.

36 Suresh, V., & Chaudhuri, D., (1993). *"Dynamic scheduling - a survey of research"*, International Journal of Production Economics 32(1), 53-63.

37 Vieira, G.E., Hermann, J.W., & Lin, E., (2000-a). *"Analytical models to predict the performance of a single machine system under periodic and event-driven rescheduling strategies"*, International Journal of Production Research 38(8), 1899-1915.

38 Vieira, G.E., Hermann, J.W., & Lin, E., (2000-b). *"Rescheduling manufacturing systems: a framework of strategies, policies and methods"*, International Journal of Manufacturing Systems 36(4), 256-266.

39 Vieira, G.E., Hermann, J.W., & Lin, E., (2003). *"Rescheduling manufacturing systems: a framework of strategies, policies and methods"*, Journal of Scheduling 6(1), 36-92.

40 Warburg, V., Hansen, T., Larsen, A., Norman, H., & Andersson, E., (2008). *"Dynamic airline scheduling: An analysis of the potentials of re-fleeting and retiming"*, Journal of Air Transport Management 14(4), 163-167.

41 Webster, S., Azizoglu, M., (2001). *"Dynamic programming algorithms for scheduling parallel machines with family setup times"*, Computers & Operations Research 28(2), 127-137.

42 Wu, S.D., & Wysk, R.A., (1989). *"An application of discrete-event simulation to on-line control and scheduling of flexible manufacturing"*. International Journal of Production Research, 27(9).

43 Xianga, W., Lee, H.P., (2008). *"Ant colony intelligence in multi-agent dynamic manufacturing scheduling"*, Engineering Applications of Artificial Intelligence 21, 73-85.

44 Zweben, M., & Fox, M., (1994). *"Intelligent scheduling"*, San Mateo: Morgan Kaufmann.

CRITICAL SUCCESS FACTORS IN IMPLEMENTING HOSPITAL INFORMATION SYSTEM IN INDONESIA: CASE STUDY PUBLIC HOSPITALS

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ABSTRACT

Nowadays offering quality health care treatment as well as reducing expenditures is becoming a priority. Thus, making Hospital Information System (HIS) becomes inevitable for hospitals. The Directorate General of Health Effort the Ministry of Health has offered a free HIS package to increase the HIS implementation especially aimed at hospitals with limited funding. However, guidance and further support in implementing the HIS is not available. Therefore, in order to provide guidance especially in minimizing the risk of the HIS implementation failure thus ensuring its success, this research is aimed at synthesizing the critical success factors (CSFs) in implementing HIS in hospitals in Indonesia. This research uses quantitative study by conducting survey and accordingly distributing questionnaires to the Directorate General of the Referral Health Effort (Bina Upaya Kesehatan Rujukan) of the Ministry of Health, three high rank officials of the Hospital Accreditation Commission (KARS - Komisi Akreditasi Rumah Sakit), eight high level management officers of two public general hospitals and one academician of Public Health. The data processing technique is performed using arithmetic mean of each question in the questionnaires. The resulted top four of the critical success factors of HIS

implementation are top management commitment, the existence of a business plan, thorough communication process and good project management. Two additional critical success factors are proposed for future work viz. all parties' commitment and sufficient human resources capability.

Keyword: critical success factors (CSFs), hospital information system (HIS), public hospital

INTRODUCTION

Hospital is comparatively different from other goods and services providers as its output is relatively less well-defined and its third-party payment and government intervention are prevalent (Danzon, 1992). However, technology innovation nowadays has brought a wave of more demanding consumers in almost every business sectors; healthcare is no exception. Offering quality health care treatment as well as reducing expenditures is becoming a priority. Therefore, Information Technology (IT) especially Hospital Information System (HIS) is inevitable for hospitals in order to meet high service quality (i.e. quick response, providing integrated and accurate patient health information, etc.) while maintaining low operation cost (Wickramasinghe and Schaffer, 2009).

In the end of 2012, some hospitals, e.g., Public Central General Hospital (RSUP) Sanglah (Denpasar), RSUP Hasan Sadikin (Bandung), RSUP Dr. Cipto Mangunkusumo (Jakarta), have implemented HIS (BUK, 2012). Other hospitals, e.g., Public District General Hospital (RSUD) Sultan Syarif Mohammad Alkadrie (Pontianak), RSUD Dr. Abdul Aziz (Singkawang), Dental and Oral Specialty Hospital (RSKGM) Bandung (Bandung), RSUD Dr. Agoesdjam (Ketapang) are also mentioned to have implemented HIS (VMT, n.d.). However, according to the Directorate General of the Health Effort, the number of hospitals implementing HIS is still considered low (BUK, 2013).

For it is most likely that funding has been the main barrier for hospitals to acquire HIS, the Directorate General has developed and offers a free software package namely the Generic Open Source Hospital Information System or simply called SIMRS GOS to hospitals (BUK, 2013). In order to get the software package, a hospital must already have IT infrastructure (network, computers, and servers) and at least one IT staff (Forum, 2013).

Although the software package can then be modified and adjusted to the needs of the hospital, the Directorate General does not provide guidance and further support for implementing SIMRS GOS in the hospital. Consequently, the hospitals will be on their own to implement SIMRS GOS as their HIS. Therefore, in order to provide guidance for implementing HIS

especially in minimizing the risk of the HIS implementation failure thus ensuring its success, this research is aimed at synthesizing the critical success factors in implementing HIS in hospitals.

This paper is organized as follows: Section 2 explains the literature review while Section 3 elaborates on the conceptual model of this research. Then, Section 4 describes the research methodology and afterward the results of the research are examined in Section 5. Subsequently, the analysis is presented in Section 6. Lastly, the final section discusses the conclusions and future works of this research.

LITERATURE REVIEW

Critical Success Factors

The definition of critical success factor from Bullen and Rockart (1981) is "the limited number of areas in which satisfactory results will ensure successful competitive performance for the individual, department or organization". It is also stated that CSFs are the few key areas where 'things must go right' for the business to flourish and for the manager's goals to be attained (Bullen and Rockart, 1981). In terms of project implementation or initiative, CSFs are described as the few items that must be handled correctly in order for a project to succeed (Schelin, 2004; McMillan, 2009; Akhavan et al., 2010). However, one must note that different project conditions (e.g., project size, project manager's work experience) and organization conditions (e.g., organization size, organization type) can exhibit different success factors as shown by an empirical study by Hyvari (2006).

Meta-Ethnography

Meta-ethnography which is introduced by Noblit and Hare could be used to synthesize qualitative research. The method involves induction and interpretation. The seven steps of the method are given as follows (Britten et al., 2002):

1. Getting started: identify the research topic
2. Deciding what is relevant to the initial interest: search variety of keywords that associated with the initial interest
3. Reading the studies: repeated reading of the selected literature and the nothing of the interpretative metaphors (can be in the form of concepts)
4. Determining how the studies are related: creating a list of the key metaphors, phrases, ideas, and/or concepts (and their relations) used in each account and to juxtapose them. Additionally, an initial assumption about the relationship between studies can be made in the form of reciprocal translation (concepts of the studies are directly comparable or similar), refutation translation (concepts of the studies stand in relative opposition to each other) or line of argument translation (concepts of the studies are not directly comparable, does not opposite each other and about so different topics).

5. Translating the studies into one another: discovering the relationships between two existing texts
6. Synthesizing translations: the step of compiling the findings of the included studies
7. Expressing the synthesis: most of meta-ethnographer will do this step in the form of written text such as writing a scientific paper

CONCEPTUAL MODEL OF RESEARCH

The synthesizing of the critical success factors for the HIS implementation will be performed using the meta-ethnography steps. Firstly, in order to obtain the generic list of the critical success factors for HIS or other healthcare systems implementation (e.g., clinical information system, etc.), a number of studies in journal or conference articles are taken from reputable and credible research database such as ScienceDirect/Scopus database using keywords "hospital information system" and "critical success factors." Based on the search results and then through reading and filtering, 3 studies, i.e., of Page (2000), Kaye et al. (2010) and Axelsson et al. (2011) are found to be highly relevant to this research topic. Table 1 exhibits the critical success factors of the HIS implementation according to Page (2000), Kaye et al. (2010), and Axelsson et al. (2011) respectively. Then, for each factor, the corresponding definitions in different texts will be examined in order to find the relationships between two existing texts. The results of translating the studies into one another are synthesized in Table 2.

Table 1 The Initial CSFs based on Page (2000), Kaye et al. (2010), and Axelsson et al. (2011)

Critical Success Factors		
Page (2000)	**Kaye et al. (2010)**	**Axelsson et al. (2011)**
Top management support	The existence of the initiative of the management in the decision to invest in IT	Top management support
Involve all relevant stakeholders in making decision	N/A	N/A
Thorough communication process	N/A	N/A
Project management	Project management	N/A
Access rights management of HIS	N/A	N/A
Automation of data	N/A	N/A
System selection	N/A	N/A
N/A	Changes in organizational structure	N/A

Critical Success Factors		
Page (2000)	**Kaye et al. (2010)**	**Axelsson et al. (2011)**
N/A	The existence of a business plan	N/A
N/A	N/A	Any adjustments to the current process in order to comply with the best practice implemented in HIS
N/A	N/A	Change management
N/A	N/A	Team composition

Table 2 The CSFs Syntheses

Critical Success Factors	Definition
Top management support	Full support from top management in IT implementation (Page, 2000; Kaye et al., 2010; Axelsson et al., 2011)
The existence of a business plan	The existence of a business plan created prior to IT implementation (Kaye et al., 2010)
Project management	The existence of good and thorough project planning (Page, 2000; Kaye et al., 2010)
Thorough communication process	Communication process is integrated, comprehensive and thorough to all parties involved (Page, 2000)
Change management	Change management program is conducted (Axelsson et al., 2011)
Team composition	Suitability of any team composition needed to be involved in the project (Axelsson et al., 2011)
System selection	The process of selecting applications is adjusted to the hospital's business

Critical Success Factors	Definition
	needs (Page, 2000)
Any adjustments to the current process in order to comply with the best practice implemented in HIS	Any adjustments to the current process in order to comply with the best practice implemented in HIS (Axelsson et al, 2011)
Changes in organizational structure	Availability of an IT unit or manager that is responsible for managing IT implementation (Kaye et al., 2010)
Involve all relevant stakeholders in making decision	Decision making process can involve all relevant stakeholders (Page, 2000)
Access rights management of HIS	The existence of defining permissions of HIS (Page, 2000)
Automation of data	The existence of the transition process to automate manual data to an electronic form (Page, 2000)

METHODOLOGY

Data Collecting Procedure

This quantitative research is using survey technique to collect the data. The survey instrument or questionnaire is developed based on the factors that are required to successfully implement HIS, each of which is described in Table 2. Additionally, in the questionnaire, the respondent is also asked to identify success factors other than that of the synthesizing phase, if any, based on his/her experience being engaged in the HIS implementation project.

Prior to distributing the questionnaires, the questionnaire is tested to ensure readability and clarity and to identify any possible shortcomings. It is tested by four academicians involved in this research (three of the Faculty of Computer Science and one of the Faculty of Public Health,

Universitas Indonesia). Then, the questionnaires are distributed directly to the management of one public central general hospital and one public district general hospital, high level officials of the Ministry of Health and the Hospital Accreditation Commission, and one lecturer of the Faculty of Public Health Universitas Indonesia.

Hospital management staff is chosen as respondents because HIS implementation project takes place in hospital and they are most likely the important actors involved in the project. Thus, it is fully reasonable to ask for their judgment on the importance of each success factor in HIS implementation. Subsequently, the Ministry of Health and the Hospital Accreditation Commission are the other stakeholders in the Indonesian Healthcare that are especially concerned with the hospital service quality standard. Therefore, the Ministry and the Commission are considered highly relevant to give judgments from the perspective of government policy-maker and accreditor respectively. Lastly, an academician is deemed necessary to fill the questionnaire with a well-founded judgment.

Instruments

In the questionnaire, there are 12 statements, all of which must be scored by the respondents for its importance. For each statement, a Likert scale of 1 to 5 is provided to indicate the degree of importance, with 1 being very unimportant, 2 being unimportant, 3 being neutral, 4 being important, and 5 being very important. The bigger the scale number, the higher the respondent's agreement level of the importance of the selected factor to be implemented in hospital in order to increase hospital service quality, and vice versa.

RESULT

Respondent Profile

Data are collected by distributing questionnaires to: (1) the management of one public central general hospital (i.e., the Head of Health Information Management Installation, the Deputy Head of Emergency Nursing, the Head of Hospital Management Information System, and the Deputy Head of General Inpatient Unit A); (2) the management of one public district general hospital (i.e., the Deputy Director of Services, the Head of Medical Record Sub Division, the Head of Emergency Unit, and two heads of inpatient rooms); (3) the Directorate General of the Referral Health Effort of the Ministry of Health; (4) the Governing Body of the Hospital Accreditation Commission (i.e., the Head of Research and Development, the Head of Education and Training, and the Head of Secretariat); and (5) one lecturer of the Faculty of Public Health Universitas Indonesia whose field of study is Hospital Administration.

Measurement

A measure of central tendency using simple arithmetic mean is used for each question in the questionnaire. As of the end of September 2013, the data that were successfully obtained is 14 questionnaires, all of which is completely filled by the above-mentioned respondents.

Mean-based Ranking Result

The arithmetic mean for each critical success factor is shown in Table 3. Table 3 exhibits that *top management support* scores nearly perfect (4.93), followed by *the existence of a business plan* (4.71) in the second position and *thorough communication process* (4.64) in the third place. In the fourth position, 4 critical success factors, i.e., *project management*, *system selection*, *any adjustment to the current process in order to comply with the best practice implemented in HIS*, and *automation of data*, are having the same score (4.57). In the fifth place, both *change management* and *team composition* hold an even score of 4.5. Then, the last three rankings, i.e., the 6th, 7th and 8th, are *access rights management of HIS* (4.43), *changes in organizational structure* (4.36), *involve all relevant stakeholders in making decision* (4.21).

Furthermore, there are also 6 additional factors mentioned by the respondents, namely *stability in which the agreed purpose and method of implementation are conducted without significant change*, *quality control*, *testing stages*, *the commitment of all parties*, *the arrangement of rules*, and *increasing the capability or competence of human resources*.

Table 3 The Ranking Results of the Critical Success Factors in Implementing HIS

Critical Success Factors of HIS implementation	Score
Top management support	4.9285714
The existence of a business plan	4.7142857
Thorough communication process	4.6428571
Project management	4.5714286
System selection	4.5714286
Any adjustments to the current process in order to comply with the best practice implemented in HIS	4.5714286
Automation of data	4.5714286
Change management	4.5
Team composition	4.5
Access rights management of HIS	4.4285714
Changes in organizational structure	4.3571429
Involve all relevant stakeholders in making decision	4.2142857

Additional success factors from respondents
Stability in which the agreed purpose and method of implementation are conducted without significant change
Quality control (achievements discussed periodically for quality achievement plan)
Testing process is done gradually to prevent total failure of the plan have been made before
The commitment of all parties
The arrangement of rules
Increasing the capability or competence of human resources

DISCUSSIONS & IMPLICATIONS

The result shows that top management support is the foremost critical success factor in implementing HIS in hospitals. This finding is in line with the study of Wong and Tein (2003) that observes top management support has been the most frequently discussed and identified in implementing ERP system as it involves significant change to the existing business process and thus requires substantial capital investment. So, it can be inferred that HIS implementation goes beyond the support of IT people for it engages more fundamental changes in the corresponding organization.

It is only logical that the organizational changes should operate towards certain goals, i.e., the business goals. A set of business goals is established by the top management. Accordingly, the organizational change or the business process change should aim at realizing the business plan. Therefore, the business plan which contains the business goals should exist prior to the IT implementation or before the business process change to be more precise. Thus, given its high importance, it is natural that the second critical success factor after the top management support is the existence of a business plan.

Regarding thorough communication process, it can be understood that this factor should be the way with which the whole changing process in the hospital can run smoothly. Thus, it is reasonable that the 3rd critical success factor after the business plan is concerning communication. Furthermore, this communication process, in our opinion should be initiated and also fully supported by the top management so that it encompasses the entire elements of the hospital and the corresponding external parties.

Next, it can be seen that, as the subsequent priority, project management in terms of good project planning organizes the implementation process that includes the business process change. The other factors in the 4th position, i.e., system selection, any adjustment to the current process in order to comply with the best practice implemented in HIS, and automation of data, are ranked the same as project management possibly because: (1) system selection is considered as a stage

in the whole implementation process steps; (2) adjustment the current process to the best practice is what is understood to be the business process change itself; (3) automation of data is recognized as one important aspect of the process change.

After the implementation process has been appropriately handled by the project management, change management is the next priority, i.e., the 5th, along with team composition that concerns choosing the right people to be involved in the implementation project. In this study, change management focuses on the transitions of the individuals and organization to a desired state (Axelsson et al., 2011). Thus, it is usually tightly coupled with the project management and it can possibly be performed in parallel with the implementation project steps.

The next ranking (6th), i.e., access rights management of HIS which concerns defining permission of HIS, in this context deals with the information governance (IG) that ensures necessarysafeguards for, and appropriate use of, patient and personal information (IG, n.d.). There has been a decree from the Minister of Health regarding the Medical and Health Information Recorder Profession Standard, i.e., KMK No. 337 Menkes/SK/III/2007 (KMK, 2007) that can be used by the project team as a starting point of the legal guidance for defining access rights of the HIS.

In the 7th place, changes in the organizational structure in terms of the availability of IT division or a manager responsible for managing IT implementation becomes the second least important factor among other critical success factors. The reason is probably because in the HIS implementation project, the project team will be dealing with not only technical and technological aspects but a more fundamental aspect viz. changing in business process, as previously mentioned. Thus, this project scope is definitely beyond what an IT division or manager can solely do for a successful implementation process although later on in the IT operation their presence is mandatory for they will be ultimately responsible for the HIS operation.

Involve all relevant stakeholders in making decision as a critical success factor, has been ranked in the last position (8th). It is possibly because the dominant approach for decision making in hospitals is top-down and that the involvement of all relevant stakeholders is sufficiently fulfilled by thorough communication process which is ranked in the 3rd position among other critical success factors. Therefore, further engagement of all relevant stakeholders to participate in a decision making is deemed less necessary. Another reasonable explanation is that making decision with all relevant stakeholders has been perceived as an exhausting experience thus highly ineffective and inefficient given the high number of the involving actors in the HIS implementation project. Thus, an alternative of involving only key actors who respectively represent relevant stakeholders could be a more preferable option for a decision making setting.

Beside the before-mentioned critical success factors, he respondents also identify 5 other critical success factors. First, the stability in which the agreed purpose and method of implementation are conducted without significant change is understood to dealing with change management issues regarding the project scope and the project parameter itself. Therefore, it is different from the 5th rank critical factor, change management. Next, quality control and testing stages are considered also as project-related critical success factors. Both factors consider the HIS as a technical system (software system). It is suggested that the quality control and the testing are performed gradually. Next, the commitment of all parties and the arrangement of rules focuses on the people aspect of the HIS implementation project. In our opinion, this commitment thing could be a potential critical success factor for implementing HIS in hospitals for this is also highly relevant to the first additional critical success factor. The last one, increasing the capability or competence of human resources is a new critical success factor that specifically deals with the people aspect. Sometimes it is necessary to upgrade the human resources capability before starting the HIS implementation project in order to support the adoption process and subsequently, the maintenance process. In conclusion, from the 5 additional critical success factors, we are highly interested to incorporate 2 factors viz., all parties' commitment and sufficient human resources capability, to the existing set of critical success factors in order to be further evaluated by a larger number of relevant respondents.

To sum up, the elaboration of each critical factor above could serve as the practical implication of this research such that hospitals especially in Indonesia could use it as guidance prior to their HIS implementation projects to minimize the risk of the project failures. Hospitals can look first at the top 4 critical success factors before they start the HIS implementation project. On the other hand, the academic contribution of this research is exhibited by the empirical result of the 10 critical success factors ranking as well as the discovery of additional potential critical success factor candidates that needs to be further studied for future works.

CONCLUSIONS AND FUTURE WORKS

In order to successfully implement HIS, hospitals should be equipped with important knowledge, i.e., critical success factors of HIS implementation. Thus, based on the research result, the top four critical success factors are top management support, the existence of a business plan, thorough communication process and good project management.

Other factors that are identified from the respondents are the stability in which the agreed purpose and method of implementation are conducted without significant change, quality control, the commitment of all parties, the arrangement of rules and increasing the capability or competence of human resources. Furthermore, from the additional factors, we propose 2 critical

success factors, i.e., all parties' commitment and sufficient human resources capability as potential candidates to be further evaluated in the future work of this research.

It is concluded that hospitals should fully realize that HIS implementation success also relies heavily on non IT-related issues; in fact the top 3 critical success factors in this study are non IT-related. Moreover, one should understand and remember that HIS implementation project goes beyond the scope of an IT division project. The HIS implementation project is unavoidably a grand project that involves the entire level and element of the hospital and might affect the organization at its essential level, viz. its business process. Therefore, a commitment at the organizational level is highly needed as previously brought up in the additional critical success factors.

The continuation of this study would be to provide guidance of high level enterprise architecture for hospital main services (i.e. outpatient, inpatient and emergency unit services) for the hospital management. Thus, the main services required to be implemented in order to exchange data with the Ministry of Health should be defined. Another future work related to this study is how the roles of the regulatory requirements can then speed up the implementation of the HIS, especially on patient tracking and other accreditation-related topic.

ACKNOWLEDGMENT

REFERENCES

1. Akhavan, P., Hosnavi, R., and Adalati, M.S. (2010), "Essential Issues in Knowledge Management System Implementation: Lessons from Iranian IT-based Companies", in the *Proceedings of the 11th International Conference, Ankara, 24 – 27 November 2010*, pp. 503-515.
2. Axelsson, K., Melin, U., and Soderstrom, F. (2011), "Analyzing Best Practice and Critical Success Factors in A Health Information System Case – Are There Any Shortcuts to Successful IT Implementation?", in the *Proceedings of the 19th European Conference on Information Systems.*
3. Britten, N., Campbell, R., Pope, C., Donovan, J., Morgan, M., and Pill, R. (2002), "Using meta ethnography to synthesise qualitative research: a worked example", *Journal of Health Services Research & Policy,* Vol. 7 No. 4, pp. 209–15.

4. BUK. (2012), "Pertemuan Koordinasi Teknis IT Dalam Rangka E-Health", available at: http://buk.depkes.go.id/index.php?option=com_content&view=article&id=224:pertemuan-koordinasi-teknis-it-dalam-rangka-e-health (accessed 4 April 2014)

5. BUK. (2013), "Ditjen BUK Sosialisasikan SIMRS Generik Open Source", available at: http://buk.depkes.go.id/index.php?option=com_content&view=article&id=376:ditjen-buk-sosialisasikan-simrs-generik-open-source&catid=1:latest-news (accessed 4 April 2014)

6. Bullen, C.V., and Rockart, J.F. (1981), "A Primer on Critical Success Factors", research report, CISR No. 69, Sloan School of Management, Massachusetts Institute of Technology, USA.

7. Danzon, P.M. (1992), "The concise encyclopedia of economics: Health Care Industry", available at:
    http://www.econlib.org/library/Enc1/HealthCareIndustry.html (accessed 4 April 2014)

8. Forum. (2013), "Forum SIMRS GOS: Mendapatkan SIMRS GOS", available at:
    http://www.buk.depkes.go.id/simrsgos/index.php?topic=3.0 (accessed 4 April 2014)

9. Hyväri, I. (2006), "Success of Projects in Different Organizational Conditions", *Project Management Journal,* Vol. 37 No. 4, pp. 31-41.

10. IG. (no date), "Information Governance", available at:
    http://www.connectingforhealth.nhs.uk/systemsandservices/infogov (accessed 9 April 2014)

11. Kaye, R., Kokia, E., Shalev, V., Idar, D., and Chinitz, D. (2010), "Barriers and Success Factors in Health Information Technology: A Practitioner's Perspective", *Journal of Management and Marketing in Healthcare*, Vol. 3 No. 2, pp. 163-175.

12. KMK. (2007), "Keputusan Menteri Kesehatan Republik Indonesia Nomor: 337 Menkes/SK/III/2007 Tentang Standar Profesi Perekam Medis dan Informasi Kesehatan", available at:
    http://www.hukor.depkes.go.id/up_prod_kepmenkes/KMK%20No.%20377%20ttg%20Standar%20Profesi%20Perekam%20Medis%20dan%20Informasi%20Kesehatan.pdf (accessed 9 April 2014)

13. McMillan, S. (2009), "Government Electronic and Mobile Service Delivery: A Success Factors Model.", Ph.D Thesis, Faculty of Business and Law, School of Management and Information Systems, Victoria University, Victoria, Australia.

14. Page, C.K. (2000), "Critical Success Factors for Implementing A Clinical Information System", *Nursing Economics Sept-Oct 2000,* Vol. 18 No.5, pp. 255-258.

15. Schelin, S.H. (2004), "Managing the Human Side of Information Technology: A Public Private Comparison of Chief Information Officers,", Ph.D. Thesis, Graduate Faculty, North Carolina State University, USA.

16. VMT. (no date), "Pengalaman Perusahaan", available at:
    http://vmt.co.id/pengalaman-perusahaan/7/ (accessed 4 April 2014)

17. Wickramasinghe, N., and Schaffer, J. L. (2009), "Critical Success Factors for E-Health", In M. Khosrow-Pour (Ed.), *Encyclopedia of Information Science and Technology Second Edition,* Hershey, PA: Information Science Reference, pp. 824-830.
18. Wong, B., and Tein, D. (2003), "Critical Success Factors for ERP Projects", In the *Proceedings of the National Conference of the Australian Institute of Project Management*, Alice Springs, October 2003.

UNDERSTANDING USERS' CONTINUANCE INTENTION TO USE MOBILE ADVERTISING: A CONCEPTUAL PAPER

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ABSTRACT

The convergence of internet and the unprecedented penetration rate of mobile phones have putting the pressure on the dollars spent from traditional media channels to internet and mobile platforms to reach its prospective customers. To assure the increase of the budget has a dollar-and-cents return, it is important to assure that the consumers continuously to adopt mobile advertising rather than its initial adoption. Recognizing the ultimate success is dependent on continuance intention, hence, the study extended Expectation-Confirmation Model (ECM) with other post-adoption constructs such as perceived ease of use, perceived enjoyment, trust, and social norms in understanding Malaysian' continuance behavior towards mobile advertising. The implications of this conceptual paper are also discussed.

Keywords: Mobile Advertising, Continuance Adoption, Expectation-confirmation model (ECM), Malaysia

INTRODUCTION

Gone were the days where the marketing messages only can be delivered via traditional media such as TV, radio, magazines, and newspapers. Recognizing the unprecedented penetration rate of mobile phones, more than 123.5 percent in 2010 (MCMC, 2010), several researchers foresee mobile devices as probable new advertising channel and media (Spurgeon, 2005; Chen and Hsieh, 2012). The rationale behind the increasing attention on mobile advertising is the results of cluttered media environment that lead marketers searching for new platform to deliver commercial messages to target customers (Khan and Allil, 2010).

Even though, the academic literature on mobile advertising is increasing, however, the topic is still immature, inconsistent, and fragmented (Varnali & Toker, 2010; Roach, 2009; Barnes and Scornavacca, 2004; Carroll et al., 2007). Likewise, the extant IS literatures heavily focus on investigating the pre-adoption behavior of mobile advertising (Khan and Alil, 2010; Yang, 2007; Okazaki, 2005), research area on mobile advertising continuance intention rarely been studied. Hence, the aim of this conceptual paper is to understand the mobile advertising continuance intention in Malaysia. Specifically, the research attempts to extend ECM with

constructs like perceived ease of use (PEOU), perceived enjoyment (PE), trust, and social norms (SN) in understanding the relationship between the model and its impact of the post-expectations constructs in mobile advertising context. The conceptual paper starts on the introduction, continued with the literature review, and proposed conceptual framework. Lastly, the conceptual paper ends with the conclusion and research implications.

LITERATURE REVIEW

Expectation Confirmation Model (ECM)

Drawing from the Expectation Confirmation Theory (ECT), Bhattacherjee (2001) developed ECM to comprehend users' information system (IS) continuance intention. Recognizing the pre-expectations and post-expectations of users' adoption behavior is dissimilar (Karahanna et al., 1999), Bhattacherjee (2001) further tailored the original ECT by transforming the mixture of pre-expectations and post-expectations model into a pure post-expectations model. Simply put, the ECM is mainly focus on "post-usage expectations" rather than "pre-use expectations" (Bhattacherjee, 2001). As a whole, ECM hypothesize that the users' post-adoption behavior lies on (1) users' satisfaction with the IS; (2) the level of users' confirmation of expectations; (3) and lastly the post-expectations variable, namely perceived usefulness.

Technology Acceptance Model (TAM)

Drawing from the Theory of Reasoned Action (TRA) initiated by Fishbein and Ajzen (1975), Technology Acceptance Model (TAM) was the most widely adopted model to explain IS adoption (Davis, 1989), TAM posits that the consumers' belief, namely PU and PEOU were linked to attitude which consecutively influence users' intention and usage of information technology. PU refers to the extent how users perceive the system that enhances their job performance. While, PEOU refers to the extent how users deems that adopting an innovation will be free of effort (Davis, 1989).
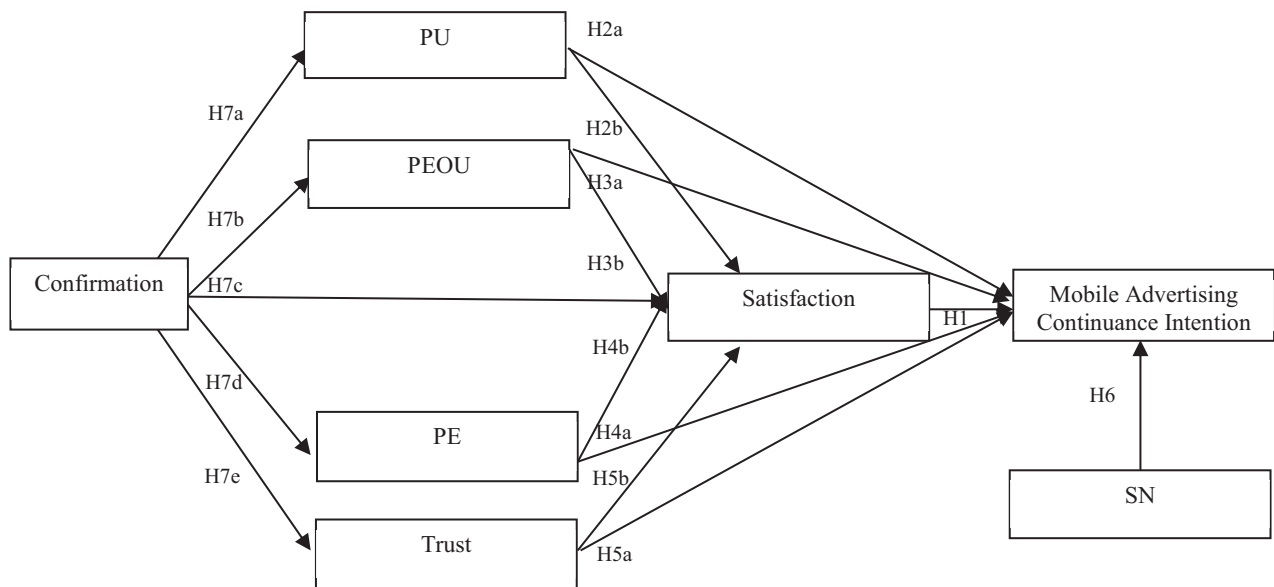
Figure 1: Conceptual Framework

Proposition Development

Among the different of IS models, ECM is extensively adopted to examine users' post-adoption setting (Kim, 2010). The model proposed so as to users' satisfaction with the system usage is vital in contributing to IS continuance intention. In the IS context, Lam et al. (2004) defined user satisfaction as an overall valuation of IS which subsequently lead to an emotional-based response about the target IS. The association between satisfaction and IS continuance intention has been confirmed by several authors such as Kim (2010) and Chong (2013). Thus, the following proposition is postulated:

H1: Malaysian' satisfaction is positively linked with their mobile advertising continuance intention.

Drawing from the ECM, users' extent of satisfaction is influenced by 2 main factors which are (1) post-adoption expectations (i.e., PU); (2) the confirmation of expectations of the IS (Bhattacherjee, 2001). In the context of mobile advertising, users develop initial expectations toward mobile advertising prior using it. Based on the users' actual use and experiences, users update their expectations towards the mobile advertising performance. If mobile advertising usage experiences outweigh to the users' initial expectations, the post-adoption expectations that influence the extent of users' satisfaction is formed. As such, the review of literatures suggested that PU (Chong, 2013), PEOU, (Ribbink et al., 2004), PE (Chong, 2013); and trust (Chiou, 2004) can elicit positive impact on satisfaction. In addition, several authors also confirmed the positive relationship between post-adoption expectations, for instance, PU and PEOU with IS continuance intention (Kim, 2010; Hong et al., 2006; Davis et al., 1989). Besides, Kim et al. (2010) also found that PE is an important construct in

shaping the mobile data service continuance intention. Recognizing that trust is a major obstacle in the adoption (Pavlou, 2003), Zhou (2013) confirmed that trust is positively linked with the mobile payment continuance intention. Thus, the following propositions are formulated:

H2a: Malaysian' PU of mobile advertising is positively linked with their mobile advertising continuance intention.

H2b: Malaysian' PU of mobile advertising is positively linked with their satisfaction with mobile advertising.

H3a: Malaysian' PEOU of mobile advertising is positively linked with their mobile advertising continuance intention.

H3b: Malaysian' PEOU of mobile advertising is positively linked with their satisfaction with mobile advertising.

H4a: Malaysian' PE of mobile advertising is positively linked with their mobile advertising continuance intention.

H4b: Malaysian' PE of mobile advertising is positively linked with their satisfaction with mobile advertising.

H5a: Malaysian' Trust of mobile advertising is positively linked with their mobile advertising continuance intention.

H5b: Malaysian' Trust of mobile advertising is positively linked with their satisfaction with mobile advertising.

SN has been long recognized as a critical factor that influences extent to which users' deemed that people who are important to them (i.e., family members and friends) think that they should behave (Fishebein and Ajzen, 1975). Kim (2010) found that SN positively influences mobile data service (MDS) continuance intention. Thus, the proposition is postulated:

H6: Malaysian' SN of mobile advertising is positively linked with their mobile advertising continuance intention.

Study by Bhattacherjee (2001) suggested that the extent of users' confirmation via the post-adoption usage experience has positively significant influence on PU. This simply explains that PU can be regulated by confirmation experience, particularly when users' initial PU is not concrete as users are still uncertain with the usage of information technology. Similarly with PU, Chong (2013) indicated that PEOU is also deemed as a post-adoption expectation in interacting with the use of information technology. For the relationship between confirmation and satisfaction, users' confirmation simply implies that users have obtained the expected outcomes via the usage experiences with information technology which in turn influences the extent of users' satisfaction positively. Several researchers further support the positive linked between users' confirmation and PE as well as trust. For example, Kim (2010) through a survey on 207 mobile data users found that confirmation positively affects PE. Whilst, Chong

(2013) found that confirmation has significant impact on trust. Thus, the propositions are postulated:

H7a: Malaysian' level of confirmation is positively linked with their PU of mobile advertising.

H7b: Malaysian' level of confirmation is positively linked with their PEOU of mobile advertising.

H7c: Malaysian' level of confirmation is positively linked with their satisfaction with mobile advertising.

H7d: Malaysian' level of confirmation is positively linked with their PE of mobile advertising.

H7e: Malaysian' level of confirmation is positively linked with their trust of mobile advertising.

CONCLUSION AND IMPLICATIONS

The conceptual paper proposed an extension of ECM in understanding Malaysian' mobile advertising continuance intention. More specifically, the proposed model extended the original ECM by adding constructs PEOU, PE, trust, and social norms. The conceptual paper has several implications. Despite the extant research heavily focus on behavioral intention to use mobile advertising, this conceptual paper is one of the earlier attempts to explore mobile advertising continuance intention in emerging market perspective. As Malaysia' mobile advertising is newly emerged and still at the early stage of development, hence, this conceptual paper enable to provide mobile stakeholders bigger picture in understanding Malaysian' mobile advertising continuance. This is critical in assisting mobile stakeholders in formulating future strategies in delivering effective marketing messages via mobile platform.

REFERENCES

1. Barnes, S. J., and Scornavacca, E. (2004), "Mobile marketing: the role of permission and acceptance", *International Journal of Mobile Communications*, Vol. 2 No. 2, pp. 128-139.
2. Bhattacherjee, A. (2001), "Understanding information systems continuance: an expectation-confirmation model", *MIS quarterly*, Vol. 25 No. 3, pp. 351-370.
3. Chen, P. T., and Hsieh, H. P. (2012), "Personalized mobile advertising: Its key attributes, trends, and social impact", *Technological Forecasting and Social Change*, Vol. 79 No. 3, pp. 543-557.
4. Chiou, J. S, (2004), "The antecedents of consumers' loyalty toward internet service providers", *Information & Management,* Vol. 41 No.6, pp. 685-695.
5. Chopng, A. Y. L. (2013), "Understanding mobile commerce continuance intentions: an empirical analysis of Chinese consumers", *Journal of Computer Information Systems,* Vol. 53 No. 4, pp. 22-30.

6. Davis, F. D. (1989), "Perceived usefulness, perceived ease of use, and user acceptance of information technology", MIS *Quarterly*, Vol. 13 No. 3, pp. 319–349.

7. Fishbein, M. and Ajzen, I. (1975), *Belief, attitude, intention and behaviour: An introduction to theory and research*, Addison-Wesley.

8. Hong, S.J., Thong, J.Y.L., and Tam, K.Y. (2006). Understanding continued information technology usage behaviour: a comparison of three models in the context of mobile internet. *Decision Support Systems,* Vol. 42 No. 3, pp. 1819-1834.

9. Karahanna, E., Straub, D. W., and Chervany, N. L. (1999), "Information technology adoption across time: a cross-sectional comparison of pre-adoption and post-adoption beliefs", *MIS quarterly*, Vol. 23 No. 2, pp. 183-213.

10. Khan, M.N., and Allil, K. (2010), "Determinants of mobile advertising adoption", *International Journal of Mobile Marketing*, Vol. 5 No.1, pp. 41-59.

11. Kim, B. (2010), "An empirical investigation of mobile data service continuance: Incorporating the theory of planned behavior into the expectation–confirmation model", *Expert Systems with Applications*, Vol. 37 No. 10, pp. 7033-7039.

12. Lam, S. Y., Shankar, V., Erramilli, M. K., and Murthy, B. (2004), "Customer value, satisfaction, loyalty, and switching costs: an illustration from a business-to-business service context", *Journal of the Academy of Marketing Science*, Vol. 32 No. 3, pp. 293-311.

13. Malaysian Communications and Multimedia Commission (MCMC) (2010), "Statistical brief number eleven: Hand phone users survey 2010", Available at: http://www.skmm.gov.my/attachment/Resources/HPUS%202010.pdf. [accessed 19 April 2012].

14. Okazaki, S. (2005), "Mobile advertising adoption by multinationals: Senior executives' initial responses", *Internet Research*, Vol. 15 No. 2, pp. 160-180.

15. Oliver, R. L. (1993), "Cognitive, affective, and attribute bases of the satisfaction response", *Journal of Consumer Research*, Vol. 20, pp. 418-430.

16. Ribbink, D., van Riel, A., Lilijander, V., and Streukens, S. (2004), "Comfort your online customer: Quality, trust and loyalty on the Internet", *Managing Service Quality,* Vol. 14 No. 6, pp. 446–456.

17. Roach, G. (2009), "Consumer perceptions of mobile phone marketing: a direct marketing innovation", *Direct Marketing: An International Journal*, Vol. 3 No. 2, pp. 124-138.

18. Spurgeon, C. (2005), "Losers and lovers: Mobile phone services advertising and the new media consumer/producer", *Journal of Interactive Advertising*, Vol. 5 No. 2, pp. 47-55.

19. Pavlou, P.A. (2003), "Consumer acceptance of electronic commerce: integrating trust and risk with the technology acceptance model", *International Journal Electronic Commerce,* Vol. 7, pp. 101-134.

20. Varnali, K., and Toker, A. (2010), "Mobile marketing research: The-state-of-the-art", *International Journal of Information Management*, Vol. 30 No. 2, pp. 144-151.

21. Yang, K. C. (2007), "Exploring factors affecting consumer intention to use mobile advertising in Taiwan", *Journal of International Consumer Marketing*, Vol. 20 No. 1, pp. 33-49.

22. Zhou, T. (2013), "An empirical examination of continuance intention of mobile payment services", *Decision Support Systems,* Vol. 54 No. 2, pp. 1085-1091.

EVALUATING THE PRICE SETTING OF FASHIONABLE DRESSES IN MOVIES IN TAIWAN

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ABSTRACT

With the popularity of the Internet and the fast development of mobile devices, the influence of mass communication become more and more powerful. Hence, the marketing of fashionable dresses started to take advantage of the power of new media, such as online movies, to affect consumers' thinking and behavior. Furthermore, prices must be one of the critical causes to change consumers' decision. The study aims to explore the acceptable prices of fashionable dresses in movies on mobile devices in Taiwan. According to the research direction, this study evaluated the price setting of fashionable dresses in movies (FDM) in Taiwan through a questionnaire finished by selected experts and designers. In addition, we applied Analytic Network Process (ANP) with the support of Kansei Engineering (KE) to evaluate the price setting of fashionable dresses in movies in Taiwan. The result of the study could contribute to the managers or designers' decision-making for the price setting of fashionable dresses in Taiwan. The results of the study shows that consumers make a decision on the basis of three criteria including: "social interaction", "social culture", and "innovative communication". The study determined the most important criteria among the three ones. Furthermore, according to practical demonstration, the study evaluated the price setting, including low, medium, and high prices, to determine the most acceptable prices of fashionable dresses in movies in Taiwan.

Keywords: Analytic Network Process (ANP), Analytic Hierarchy Process (AHP), fashionable dresses, mobile devices, online movies, Kansi Engineering

INTRODUCTION

From earlier works, such as "The Girl With Dragon Tattoo", "The Devil Wears Prada", to recent ones, such as "Hunger Game 2", The upsurge driven by fashionable dresses has never diminished.

Fig. 1 shows fashionable dresses in movies

Foreign designers felt the great mass fervor and foreseen the business of fashionable dress. Then, the designers cooperated with shopping websites to promote a series of dresses for perking up to the feverish subject of a talk and stimulating sales. In order to have a successful sale, price setting could be the most critical concept. A new method for setting price for FDM in this study, based on the ANP which is supported by Kansei Engineering. Kansei Engineering, using a more professional and strict procedure, take the place of the role of decision maker to decide the elements and their corresponding factors. Analytic Network Process (ANP) is applied in this study to decide the best price setting for the sale of fashionable dresses in movies (FDM) in Taiwan. Decision of the appropriate price setting of FDM can be viewed as a complex multicriteria decision-making problem, including economic, social, or design factors. The decision-making process includes the identification of three price settings of FDM and 16 criteria grouped into six critical factors for the construction of a network. Two professional designers, one sale manager and three scholars related to communication acted as experts and decision makers.

BACKGROUND OF ANP, KANSEI ENGINEERING, EGM, AND QTTI

The method of Analytic Network Process (ANP) are proposed by Saaty (Saaty, 1980, 1996a, 2001, 2005, 2008). In this study, the reasons for using an ANP-based decision analysis approach because the price setting of FDM is a multicriteria decision problem. Basically, the ANP model comprises the following steps (Aragone´ s-Beltra´n et.al, 2010):

(i)   Identifying the components and elements of the network and their relationships.

(ii)   Conducting pairwise comparisons on the elements.
(iv)   Conducting pairwise comparisons on the clusters.

Recent applications of ANP to decision-making problems related to product design and consumer behavior have been disclosed as follows: Purchasing decisions (Demirtas and Ustun, 2009), concept evaluation in a new product development (Ayağ and Ö zdemir, 2007), product mix planning (Chung et al., 2005), selection of best actuation for end-of-life computers (Ravi et al., 2005).

Kansei Engineering is a method for studying user preferences for products. The method can be used to evaluate the results of the interaction between humans and products. Kansei Engineering can evaluate this interaction by considering the person's original perceptions and emotions rather than simply by the method of interaction. "Kansei" is similar to a semiotic system, which is designed to determine human affection and preference to products. Thus, from the viewpoint of Kansei Engineering, which can be used in the study of the design of customer-centred products, a very import issue for developers and designers is the type of feeling that a product evokes in its users. Thus, the method of Kansei Engineering is appropriate for the evaluation of a user's impressions of fashionable dresses in movies on mobile devices. This method of study can be used to develop a system of investigation and analysis of the attraction, cognition, and perception of games, in order to provide support for designers and evaluation groups. For example, Nagamachi (2008) used the method of Kansei Engineering to establish a hierarchy of the values in a customer's life. Kansei Engineering studies can also be used to assess dress style and dress design. Subjective evaluation, which is dependent on different semantics, can be analysed through multivariate statistical analysis. The relationship between impression and style characteristics can then be determined and can be used to support the creation of a desired design proposal.

In this study, the EGM, as a qualitative analysis tool widely applied to Kansei Engineering, was used to determine the potential appeal factors and elements for ANP analysis. Then, EGM hierarchical diagram of the appeal factors and specific design chacteristics for fashionable dresses was constructed. Sanui (1996) integrated the repertory grid method into the EGM in two processes. First, the objects to be compared were assessed, and participants were asked to answer what is good or bad as well as their likes and dislikes about them. Second, the meaning or conditions of their answers were clarified through additional questions.

For determining elements for ANP analysis, this study adopted the Quantification

Type I Method as a tool to quantitatively analyse the importance of the appeal factors of fashionable dresses in movies. In addition, elements were measured and quantified using the importance-levels from the original evaluation. Using multiple linear regression methods, Hayashi's (1950) Quantification Theory Type I can statistically predict the relationship between a response value and the categorical values.

THE DECISION PROCESS AND THE ANP MODELING APPROACH

Description of the decision-making process

In this study, the decision-making process was divided into three phases: problem analysis, ANP analysis and evaluation. The phase of problem analysis was supported by Kansei Engineering in this study. In the phase of ANP analysis, ANP network-based model was used for analyzing the influences among network elements. The phases of evaluation were conducted for evaluating final results and conclusion depended on the ANP decision analysis. Two professional designers, one sale manager and three scholars related to communication acted as the key experts for conducting Kansei Engineering and decision makers for executing ANP analysis.
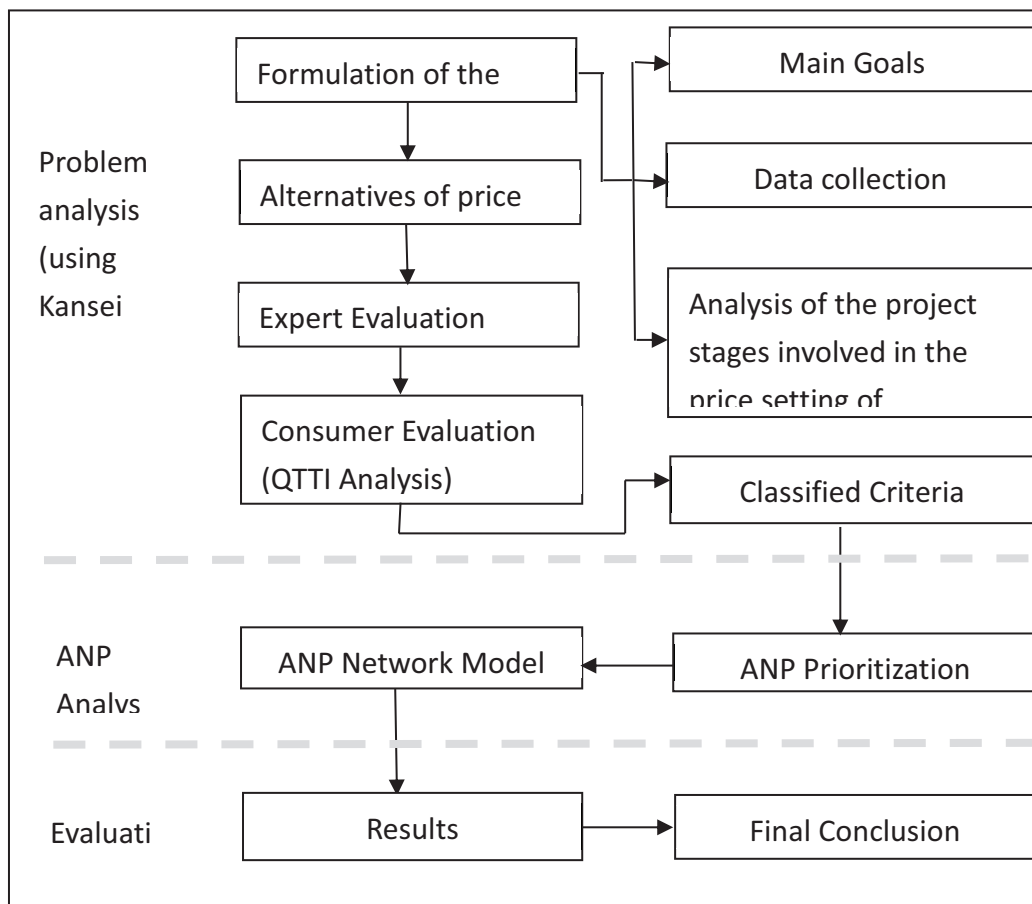
Fig. 2. Decision making process in this study

Phase of problem analysis

The decision problem was formulated with the support of Kansei Engineering. The criteria for evaluating the alternatives were identified and grouped into factors according to the result of Kansei Engineering for further ANP analysis.

We created the evaluation structure from answers given by the 6 experts who participated in the interviews using the EGM. The appeal factors of fashionable dresses in movies were determined according to the preference interviews and using the EGM. The greatest factors of appeal of fashionable dresses in movies were found to be "chic", "unique", "communicable", "sexy", "stratified" and "elegant", as determined from the evaluation. The consumers chose an fashionable dresses mainly because of one or more of the following 16 characteristics: "Stunning", "Glamorous", "Modern", "Personalized", "Creative", "Dominant", "Authoritative"
"Empathic", "Feminine", "Masculine", "Neutral", "Patrician", "Democratic", "Qualitative", "sophisticated", and "Classic". Then, all the factors were proved to have influence on the appeal of FDM based on the analysis of QTTI. These factors and characteristics were used as the elements for ANP analysis. More specifically, the 16 characteristics were viewed as the criteria which were grouped into factors so all the elements needed in ANP were identified. The 16 criteria were as follows:

Factor A: Chic

   a1- Stunning. It assesses how FDM make audiences feel impressive.

   a2- Glamorous. It assesses how audiences feel the attraction of FDM.

   a3- Modern. It assesses how audiences feel that FDM is modern.

Factor B: Unique

  b1- Personalized. It assesses that how audience feel that FDM is personalized.

  b2- Creative. It assesses that how audience feel that FDM is creative.

Factor C: Communicable

  c1- Dominant. It assesses that how audience feel that FDM is dominant.

  c2- Authoritative. It assesses that how audience feel that FDM is authoritative.

  c3-Empathetic. It assesses that how audience feel that FDM is empathetic.

Factor D: Sexy

  d1- Feminine. It assesses that how audience feel that FDM is feminine.

  d2- Masculine. It assesses that how audience feel that FDM is masculine.

  d3- Neutral. It assesses that how audience feel that FDM is neutral.

Factor E: Stratified

  e1- Patrician. It assesses that how audience feel that FDM is patrician.

e2- Democratic. It assesses that how audience feel that FDM is democratic.

Factor F: Elegant

f1: Qualitative. It assesses that how audience feel that FDM is qualitative.

f2: Sophisticated. It assesses that how audience feel that FDM is sophisticated.

f3: Classic. It assesses that how audience feel that FDM is classic.

Phase of ANP

In this phase, the decision criteria were weighted; then each alternative was evaluated for each criterion so as to obtain the desired final priority order of the alternatives under study (Aragone´s-Beltra´n et.al, 2010). Hence, ANP methods generally have two main decision analysis models, including one hierarchy model and another network-based model. In the former one the main goal of the problem is laid at the top place: the price setting of FDM. At the bottom of the hierarchy place the three possible price levels. The intermediate levels show the structure of the criteria factors.

Table 1 Structure of the hierarchy model.

Goal	Group	Criteria	Alternatives
	(A) Chic	(a1) Stunning	High Price
		(a2) Glamorous	Medium Price
		(a3) Modern	Low Price
	(B) Unique	(b1) Personalized	
		(b2) Creative	
	(C) Communicable	(c1) Dominant	
		(c2) Authoritative	
		(c3) Empathic	
	(D) Sexy	(d1) Feminine	
		(d2) Masculine	
		(d3) Neutral	
	(E) Stratified	(e1) Patrician	
		(e2) Democratic	
	(F) Elegant	(f1) Qualitative	
		(f2) Sophisticated	
		(f3) Classic	

In the latter one the study use a single network model consisting of 4 clusters, including the cluster of the goal, the cluster of 6 factors, the cluster of criteria comprising the 16

elements, and the cluster of the alternatives. The procedure followed is as described below: determination of the network and priorities among elements

For determining the network, experts were asked about the influences that each criterion exerted on the other criteria. As there are 16 criteria, this means 188 questions of the type. After the data were collected from the questionnaire, the decision model was established with the support of the Super Decisions v2.2.6. Fig. 3 shows the relationships and organization among the clusters.
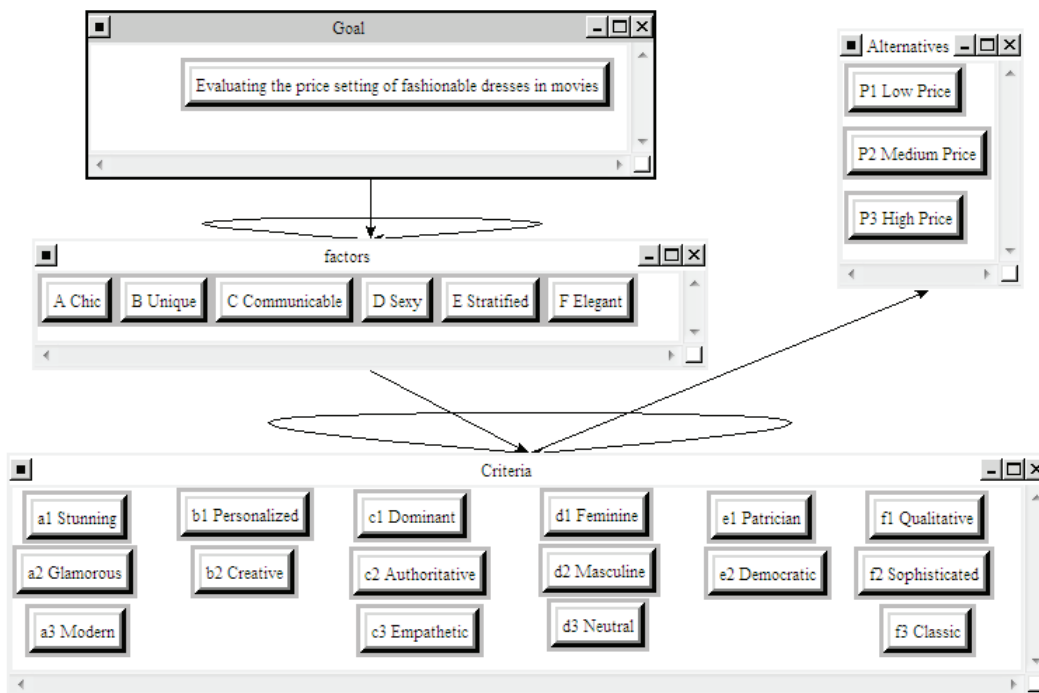
Fig. 3. Structure of the relationships among clusters.

For determining the priorities among elements, questionnaire about priorities was designed to be answered by the experts. This questionnaire analyzed each element, including factors and criteria, in terms of which of the other elements that influence it and belong to a certain factor exerts a greater influence on it and to what extent. This is carried out by means of the method of pairwise comparison. The questionnaire was integrated into tables that arranged the questions using the pairwise comparison matrices. The consistency ratios of the judgment matrices were not higher than 0.1. Tables 2, 3, 4, 5, and 9 present an example of the questionnaire.

Table 2 Example of the questionnaire about prioritization of factors:

1.   Compare the following factors on behalf of different element groups according to their influence upon accesses in the goal "**Evaluating the price setting of fashionable dresses in movies**". Then, please check in the box below. Before comparing them, please fill the importance in the three elements in order according to personal subjective evaluations (1~3 no repetition).

◎ （ 3 ） Chic   A ◎ （ 6 ） Unique   B ◎ （ 1 ） Communicable C

◎ （ 5 ） Sexy   D ◎ （ 2 ） Stratified   E ◎ （ 4 ） Elegant   F

Factors	Extreme 9:1	8:1	Very 7:1	6:1	Strong 5:1	4:1	Relative 3:1	2:1	Equally 1:1	Relative 要 1:2	1:3	1:4	Strong 要 1:5	1:6	Very 1:7	Extreme 1:8	1:9	Opposite
A					x													B
													x					C
					x													D
											x							E
								x										F
B																x		C
										x								D
														x				E
													x					F
C		o																D
							x											E
					x													F
D														x					E
										x								F
E						x													F

Table 3 Example of the questionnaire about prioritization and dependence among factors:

2-1. Compare the following factors on behalf of different element groups according to their influence upon accesses in the impression "**Chic"**. Then, please check in the box below. Before comparing them, please fill the importance in the three elements in order according to personal subjective evaluations (1~3 no repetition).

◎（ 1 ）Communicable C ◎（ 3 ）Stratified　E ◎（ 2 ）Elegant　　　F

Factors	Extreme		Very		Strong		Relative		Equally		Relative		Strong 要		Very		Extreme	Opposite
	9:1	8:1	7:1	6:1	5:1	4:1	3:1	2:1	1:1	1:2	1:3	1:4	1:5	1:6	1:7	1:8	1:9	
C	x																	**E**
					x													**F**
E													x					**F**

Table 4 Example of the questionnaire about prioritization of elements within a factor:

3-1. Compare the following elements in the group **A** according to their influence upon accesses in the impression "**Chic"**. Then, please check in the box below. Before comparing them, please fill the importance in the three elements in order according to personal subjective evaluations (1~3 no repetition).

◎（ 1 ）Stunning　　a1
◎（ 2 ）Glamorous　a2
◎（ 3 ）Modern　　　a3

Factors	Extreme		Very		Strong		Relative		Equally		Relative		Strong 要		Very		Extreme	Opposite
	9:1	8:1	7:1	6:1	5:1	4:1	3:1	2:1	1:1	1:2	1:3	1:4	1:5	1:6	1:7	1:8	1:9	
a1					x													**a2**
	x																	**a3**
a2					x													**a3**

Table 5 Example of the questionnaire about prioritization and dependence of elements among different factors:

4-1. Compare the following elements in different groups according to their influence upon accesses in the element "**Stunning (a1)**". Then, please check in the box below. Before comparing them, please fill the importance in the five elements in order according to personal subjective evaluations (1~5 no repetition).
◎（ 1 ）Glamorous a2 ◎（ 2 ）Modern a3 ◎（ 5 ）Creative b2
◎（ 3 ）Patrician e1 ◎（ 4 ）Classic f3

Factors	Extreme 9:1	8:1	Very 7:1	6:1	Strong 5:1	4:1	Relative 3:1	2:1	Equally 1:1	Relative 1:2	1:3	Strong要 1:4	Very 1:5	1:6	Very 1:7	1:8	Extreme 1:9	Opposite
a2						o												a3
	o																	b2
					o													e1
			o															f3
a3					o													b2
							o											e1
					o													f3
b2													o					e1
											o							f3
e1								o										f3

Table 9 Example of the questionnaire about prioritization between elements and alternatives:

5-1 Compare the following alternatives according to their influence upon accesses in the element "**Stunning (a1)**". Then, please check in the box below. Before comparing them, please fill the importance in the five elements in order according to personal subjective evaluations (1~3 no repetition).
◎ (3)P1　Low Price ◎ (2)P2　Medium Price ◎ (1)P3　High Price

Alternatives	Extreme		Very		Strong		Relative		Equally		Relative		Strong		Very		Extreme	Opposite
權重	9:1	8:1	7:1	6:1	5:1	4:1	3:1	2:1	1:1	1:2	1:3	1:4	1:5	1:6	1:7	1:8	1:9	權重
P1													o					P2
																	o	P3
P2													o					P3

3.4. Phase of evaluation of results

Table 6 Priorities of the price setting depending on the decision model used

Alternatives	ANP Priority	Ranking
Low Price	0.15497	3
Medium Price	0.38522	2
High Price	0.4598	1

Table 7 Comparison of the priorities of the criteria depending on the decision model used**.**

Criteria	ANP
a1 Stunning	0.20151
a2 Glamorous	0.23562
a3 Modern	0.09145
b1 Personalized	0.11835
b2 Creative	0.02223
c1 Dominant	0.05534
c2 Authoritative	0.02875
c3 Empathetic	0.11778

d1 Feminine	0.0233
d2 Masculine	0.00001
Criteria	ANP
d3 Neutral	0
e1 Patrician	0.049
e2 Democratic	0.01313
f1 Qualitative	0.001
f2 Sophisticated	0.01539
f3 Classic	0.02715

Table 8 Comparison of the priorities of the criterion factors

Factors	ANP	Ranking
A Chic	0.0551	6
B Unique	0.16327	4
C Communicable	0.25918	1
D Sexy	0.07347	5
E Stratified	0.21837	3
F Elegant	0.23061	2

Table 6 showed that Alternative High Price was rated with the highest priority value of 45.9%. On the contrary, Alternative Low Price was rated with the lowest priority value of 15.4%. This means that, in the aspect of setting prices for FDM, High Price is the best option for the price setting of FDM and Low price is the worst alternative. In addition, Table 7 shows different weights of criteria obtained in ANP model. Table 8 showed that Communicable was best rated with the priority value of 25.9%. This means that Factor Communicable had the most influence on the decision-making for the price setting of FDM.

CONCLUSIONS

This paper shows a new approach for the decision-making for the optimal price setting of fashionable dresses in movies on mobile devices, based on the ANP method with the help of Kansei Engineering and. This is a complex decision-making problem because many different criteria and factors need to be considered. Kansei Engineering techniques are very useful to support the execution and reliability of ANP model. This study successfully help the decision-making for the price setting of FDM. Hence, the result of this study could contribute to the field of communication technology and management.

REFERENCES

1. Ayag̃, Z., Ö zdemir, R.G., 2007. An analytic network process-based approach to concept evaluation in a new product development environment. Journal of Engineering Design 18 (3), 209–226.

2. Aragoné s-Beltrá n, P., Pastor-Ferrando, J. P., Garcı́a-Garcı́a, F., and Pascual-Agulló, A., 2010. An Analytic Network Process approach for siting a municipal solid waste plant in the metropolitan area of Valencia (Spain). Journal of Environmental Management 91, 1071-1086

3. the Metropolitan Area of Valencia (Spain)

4. Chung, S., Lee, A.H.I., Pearn, W.L., 2005. Analytic network process (ANP) approach for product mix planning in semiconductor fabricator. International Journal of Production Economics 96, 15–36.

5. Demirtas, E.A., Ustun, O., 2009. Analytic network process and multi-period goal programming integration in purchasing decisions. Computers and Industrial Engineering 56 (2), 677–690.

6. Emek, E., Kara, B.Y., 2007. Hazardous waste management problem: the case forincineration. Computers and Operations Research 34, 1424–1441

7. Go´mez-Navarro, T., Garcı́a-Melo´ n, M., Acun̈a-Dutra, S., Dı́az-Martı́n, D., 2009. An environmental pressure index proposal for urban development planning based on the analytic network process. Environmental Impact Assessment Review 29, 319–329.

8. Hale, T., Moberg, C.R., 2003. Location science research: a review. Annals of Operations Research 123, 21–35.

9. Hayashi, C. (1950), "On the quantification of qualitative data from the mathematico-statistical point of view", Annals of the Institute of Statistical Mathematics, Vol. 2 No. 1, pp. 35-47.

10. Nagamachi, M. (2008), "Perspectives and the new trend of Kansei/affective Engineering", The TQM Journal, Vol. 20 No. 4, pp. 290-8.

11. Ravi, V., Shankar, R., Tiwari, M.K., 2005. Analyzing alternatives in reverse logistics for end-of-life computers: aNP and balanced scorecard approach. Computers and Industrial Engineering 48, 327–356.

12. Saaty, T.L., 1980. The Analytic Hierarchy Process. Mc Graw-Hill.

13. Saaty, T.L., 1994. Fundamentals of Decision Making and Priority Theory with the AHP. RWS Publications, Pittsburgh.

14. Saaty, T.L., 1996a. The Analytic Network Process: Decision Making with Dependence and Feedback. RWS Publications, Pittsburgh.

15. Saaty, T.L., 2001. Decision Making with Independence and Feedback: The Analytic Network Process. RWS Publications, Pittsburgh.

16. Saaty, T.L., 2005. Theory and Applications of the Analytic Network Process: Decision Making with Benefits, Opportunities, Costs and Risks. RWS Publications, Pittsburgh.

17. Saaty, T.L., 2008. Relative measurement and its generalization in decision making. Why pairwise comparisons are central in Mathematics for the measurement of intangible factors. The analytic hierarchy/network process. Revista de la Real Academia de Ciencias Exactas, Fı́sicas y Matemá́ ticas (RACSAM) 102 (2), 183–191.

18. Sanui, J. (1996), "Visualization of users' requirements: introduction of the evaluation grid method", Proceedings of the 3rd Design & Decision Support Systems in Architecture & Urban Planning Conference, Vol. 1, pp. 365-74.

THE RELATIONSHIP WITHIN PHYSICAL ATTRACTIVENESS OF COSMETIC MEDICINE EMPLOYEE, PERCEIVED RISK, AND CONSUMER'S PRICE SENSITIVITY

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ABSTRACT

Cosmetic medicine is an emerging and well developed industry over the past decade. In receiving services of cosmetic medicine, consumers have frequent contact with employees. The most important clue for consumers is the appearance of employees (Bitner, 1992; Lovelock and Wright, 1999). Physical attractiveness is an employee's character that is most apparent and easily observed, and consumers will take it as the basis of their judgment and behavior (Caballero and Solomon, 1984; Solnick and Schweitzer, 1999). Price is also an important factor in consumption. In this study, some issues are discussed and clarified - the relationship between physical attractiveness of cosmetics employee and consumer's price sensitivity, and the mediating effects of perceived risk and professional competence.

After collecting 366 effective questionnaires of consumers with medical cosmetics experience, the results of this study are: physical attractiveness of cosmetics employee has a negative effect on perceived risk, but a positive effect on professional competence. Both perceived risk and professional competence have positive effects on consumer's price sensitivity, and partial mediating effects on the relationship between physical attractiveness of cosmetics employee and consumer's price sensitivity. A negative relationship between physical attractiveness of cosmetics employee and consumer's price sensitivity does not exist.

According to the above results, this study offers suggestions for employers. They can hire employees with higher physical attractiveness and professional competence. In this way, they can make consumers more willing to accept the service, as their perceived risks are minimized. Moreover, they can offer better service after medical cosmetics, which may promote consumers' to revisit and increase the frequency of accepting service again.

Keywords: cosmetic medicine, physical attractiveness, price sensitivity

INTRODUCTION

Modern people are concerned about beauty care, and in addition to increasing their aesthetic appearance to cope with social activities, they expect to look healthy, beautiful, and confident through technological advancements of cosmetic medicine (Stokes and Fredrick,

2003). According to market estimates, Taiwan's cosmetic medical market can be up to 60 billion NTD per year, and anti-ageing and anti-wrinkling cosmetic medical products can be worth NT$4.6 billion NTD. The annual growth rate of hyaluronic acid anti-wrinkle products, with significant effect in a short period of time, can be up to 20% (Lee, Wu, Lin, and Lee, 2014).

Cosmetic medicine combines medical professionalism and beauty techniques, which focus on non-invasive medical technology to improve or change physical appearance and shape, and achieve cosmetic purposes (Lee et al., 2014). The cosmetic medicine industry is a service industry, thus, cosmetic medical service personnel with medical knowledge and beautification skills play the most important role. To consumers, the service employee's physical attractiveness is one of the most conspicuous and most easily observed personal characteristics (Reingen, Ronkainen and Gresham, 1981; Patzer, 1983; Caballero and Solomon, 1984). Consumers may have a preliminary attitude or response due of physical appearance, or may have expectations of service employee's appearance, as based on previous experience or impression (Koernig and Page, 2002).

In an open market system, the patients of cosmetic medical treatment are consumers. For consumers, price is a key factor when purchasing products or services (Puri, 1996; Piron, 1991; Bellenger et al., 1978). When faced with product or service price changes, the degree of perception and response is price sensitivity. When the consumer price sensitivity is higher, the consumer will have a clearer impression of the price of purchase (Monroe, 1973).

Most previous studies on physical attractiveness discussed the advertising models or endorsers' physical attractiveness. Attractive advertising models can result in higher reliability of consumers (Bower and Landreth, 2001), more favorable advertising comments (Baker & Churchill, 1977; Petroshius and Crocker, 1989), and thereby, promote the higher purchase intention of consumers (Caballero and Pride, 1984; Ohanian, 1991). Those with greater physical attractiveness have an advantage (Patzer, 2011) as they can get more friendships (Greitemeyer, 2013), as well as positive reactions (Eastwick, Eagly, Finkel, Johnson and Sarah, 2011), in order to achieve success in their tasks (Patzer, 2013). Most studies on price sensitivity focused on the changes in price sensitivity, as caused by company marketing strategy (Krishnamurthi and Papatla, 2003), product price expectations (Danes and Lindsey-Mulikin, 2012), or consumer characteristics (Sirvanci, 1993; Kim, Srinivasan and Wilcox, 1999). In addition, product characteristics (Sirvanci, 1993), self-price changes, competitive brand discounts (Han, Gupta, and Lehmann, 2001), consumption situations, social background (Wakefield and Inman, 2003), brand parity (Erdem, Swait and Louviere, 2002; Ramirez and Goldsmith, 2009), brand loyalty, and consumer innovativeness (Ramirez

and Goldsmith, 2009) have been confirmed to affect price sensitivity.

The cosmetic medical service is an industry relating to attractiveness, in terms of service type. The service personnel physical attractiveness will affect consumers' evaluation and purchase intention (Ronkainen and Reingen, 1979; Reingen, Gresham, and Kernan, 1980; Kahle and Homer, 1985; Kamins, 1990; Parekh and Kanekar, 1994). However, whether physical attractiveness is related to price sensitivity has never been discussed in previous literature. This is the purpose of the present study.

LITERATURE REVIEW

Cosmetic Medicine is an emerging medical industry in recent years. The use of technology in the industry covers clinical departments relating to beauty care (Lee et al., 2014). Through advances in medical technology and bio-technology, it can effectively solve skin defects or illness to achieve the effect of cosmetic medicine. Cosmetic medicine has convenient, safe, and approachable price characteristics, thus, the development of the industry is thriving (Lee et al., 2014).

Reasons for the popularity of cosmetic surgery include: technical advances in cosmetic medicine, lower costs of medical treatment, the social environment of people having more disposable income, and greater attention paid to appearance. Consumers will choose to change their appearance because of negative thoughts, feelings, or experiences, and cosmetic medicine allows them to improve relationships and change social perceptions. Therefore, the psychological state of consumers before consumption should be explored (Grossbart and Sarwer, 1999). People believe that they can feel better about themselves, enhance their interpersonal skills, improve self-esteem and emotional stability, and even be more confident after cosmetic medical treatment (Stokes and Frederick, 2003).

Physical Attractiveness refers to "the pleasing degree of the target person" (Patzer, 1983). In interpersonal relationships, most people notice the appearance of others, and the appearance often affects their perception of others, or triggers favorable feelings (Morrow, 1990). Whether static or dynamic attraction (Riggio, Widaman, and Tucker, 1991), it will cause a positive emotional response of others, produce positive reinforcement effects, and trigger the behavior of others trying to become close (Burns, 1987). Physical attractiveness conveys the ideal image of the individual mind, which can lead to profound feelings of pleasure (Hatfield and Sprecher 1986).

From the social psychological point of view, in developing long-term relationships, most people tend to choose people with more attractive appearance as objectives. First, from the

aesthetic angle, people love beautiful people; secondly, people have more expectations of reward in the contact with more attractive people; thirdly, due to the stereotyping of attraction, namely, the concept of "What is beautiful is good", people tend to believe that more attractive people have other good characteristics (Addis and Myers, 2012).

Physical attractiveness is the most obvious and observable characteristic of service personnel (Caballero and Solomon, 1984; Dion, Berscheid and Walster, 1972; Patzer, 1983; Reingen, Ronkainen and Gresham, 1981). Consumers may have different attitudes or reactions according to service personnel's physical attractiveness. The results of a large number of studies also suggest that physical attractiveness has a significant influence on consumer judgment and behavior (Dion, 1972). The service employee's appearance can affect consumer behavior (Baker, 1977), and convey service messages (Berry, 1980; Caballero and Solomon, 1984; Solnick and Schweitzer, 1999).

As proposed by Bauer (1960), *the concept of perceived risk* argues that the purchase of consumers may lead to unpredictable results that can be regarded as risks. Therefore, consumption behavior is the taking of risks. The perception of uncertainty or unfavorable results of consumers (Dowling and Staelin, 1994), or the probability of the individual evaluation of situational uncertainty and the controllable degree (Baird and Thomas, 1985) are perceived risks. Therefore, perceived risk is the possibility of consumer perception of unfavorable results after purchase, and the subjective perception of loss degree when the purchase results fail to meet the expected goals (Cox, 1967).

Studies on service products found that perceived risk is a situational and personal consumption behavior structure, which may affect the purchase of commodities or services, as well as the selection of stores. When the consumer has a certain need and learns about the differences in brands after collection and comparison of brand information, the consumer may have perceived risks (Dowling, 1986; Chaudhuri, 1998). The perceived and tolerable risk degree of the consumers determines the purchase strategy, intention (Mitra et al., 1999), and purchase behavior (Peter and Tarpey, 1975).

Price sensitivity: many studies indicate that consumers are not necessarily able to remember the original purchase price of a product, and in fact, rely on their inherent "price reference system" –as internalized perceived prices to assess product prices. The feelings of the consumer, as based on perceived price, do not come from the reasonable judgment of the prices according to the actual price or the objective price, but instead, comes from the internal price reference system (Zeithaml, 1982; Estelami and Maeyer, 2004).

RESEARCH HYPOTHESIS

Based on the fit hypothesis, when the service type is associated with attractiveness, if the service employee's physical attractiveness is higher, the consumer is more willing to pay for the service (Koernig and Page, 2002). Cosmetic medicine is a service relating to attractiveness, and if the service employee's physical attractiveness is higher, it can better promote the image of professional service and enhance consumer recognition and perceived trust (Ferguson, 2012). Therefore, if the service employee's physical attractiveness is higher, it can better display a positive image of high degree professionalism. Consumers are more interested in the information and cues provided by highly professional sales personnel, and can conduct an evaluation of professional expertise of the service expertise (Homburg and Stock, 2004). Therefore, when the purchasing target can stratify the target professional level, the interference effect of inconsistency, as generated by the risk of purchase decision-making behaviors (Cox, 1967), will be decreased (Campbell and Goodstein, 2001).

> *H1: If the service employee's physical attractiveness is higher, then the consumer perceived financial risk is lower.*
>
> *H2: If the service employee's physical attractiveness is higher, the consumer perceived performance risk is lower.*
>
> *H3: If the service employee's physical attractiveness is higher, then the consumer perceived physical risk is lower.*

During the process of purchasing products or receiving services, the most important cue is the appearance of the service employee (Bitner, 1992; Lovelock and Wright, 1999). Attractive physical appearance can cause positive emotional responses, generate positive enhancement effects, and trigger similar behaviors of others (Burns, 1987). People are often affected by the halo effect of "What is beautiful is good", by assuming that people with attractive appearance have other good conditions (Addis and Myers, 2012).

The cosmetic medicine is an industry relating to beauty. If the service employee's physical attractiveness increases, the consumer's preference will also increase (Koernig and Page, 2002). In addition, if the service employee's physical attractiveness is higher, the service employee will be regarded as having better sales skills (Reingen, Gresham, and Kernan, 1980; Ronkainen and Reingen, 1979), thus, the consumer evaluation will be higher (Kahle and Homer, 1985; Kamins, 1990; Parekh and Kanekar, 1994), which can enhance consumer interaction and purchasing intention (Reingen et al., 1980). Therefore, subject to the halo effect of "What is beautiful is good", if the service employee's physical attractiveness increases, consumers will have a positive impression regarding image and service, which can also affect the perceived psychological risk and social risk (Peter and

Tarpey, 1975). Therefore, this study proposed the following hypothesis of this study:

> *H4: If the service employee's physical attractiveness is higher, then the consumer perceived psychological risk is lower.*
>
> *H5: If the service employee's physical attractiveness is higher, then the consumer perceived social risk is lower.*

Perceived risk can affect the tendency and intention of consumers to purchase a product or service (Dowling, 1986), and can directly affect the consumer's purchase intention (McKnight et al., 2002). When consumers are making purchasing decisions, price is the payment for service or product (Peter et al., 1990). Consumers mostly rely on the intrinsic "price reference system", that is, the perceived price to evaluate the product price (Zeithaml, 1982; Estelami and Maeyer, 2004). Therefore, when consumer perceived financial risk, performance risk, physical risk, psychological risk, and social risk exist, consumer price sensitivity is an important factor of purchase decision making behaviors. Therefore, this study proposed the following hypothesis of this study:

> *H6: If consumer perceived financial risk is lower, then the price sensitivity is lower.*
>
> *H7: If consumer perceived performance risk is lower, and then the price sensitivity is lower.*
>
> *H8: If consumer perceived physical risk is lower, and then the price sensitivity is lower.*
>
> *H9: If consumer perceived psychological risk is lower, and then the price sensitivity is lower.*
>
> *H10: If consumer perceived social risk is lower, the price sensitivity is lower.*

METHODOLOGY

Settings and samples

This study employed the convenience sampling method, and samples were taken from outpatients of cosmetic and laser centers in regional teaching hospitals, regional hospitals, and medical centers. Each research location included five hospitals each in northern, central, and southern Taiwan; 60 questionnaires were distributed to each hospital. All 900 participants were given an assurance of confidentiality and were told that there was no right or wrong answer to the questionnaire items. Respondents self-administered the questionnaires. By the cut-off date for data collection, 366 questionnaires were retrieved, indicating a response rate of 40.6%.

To minimize the effect of the common method variance (CMV), 3 different approaches were employed in designing the questionnaire. First, open-ended questions were interspersed

throughout the questionnaire in order that respondents did not fall into a pattern linked to Likert or semantic differential scales. Second, the anchors for the scales were varied for different constructs. Finally, some items in the questionnaire were reverse coded. After collecting the data, Harman's one-factor test was used to test for CMV. If CMV were a serious problem in this study, we would expect a single factor to emerge from a factor analysis or one general factor to account for most of the covariance in the criterion variables (Podsakoff and Organ, 1986). This study performed factor analysis on all items, extracting 6 factors with eigenvalues greater than one. Furthermore, no general factor was apparent in the unrotated factor structure, with Factor 1 accounting for less than 20% of the variance. Thus, the design of the questionnaire, as well as the post hoc test, suggested that CMV was not of great concern

Measures

This research measured independent variables – physical attractiveness, and dependent variable – price sensitivity. In addition, we measured the explanatory variables of our hypotheses – financial risk, performance risk, physical risk, psychological risk, and social risk.

Physical attractiveness: The scale used to measure physical attractiveness consisted of 5 items from Ohanian (1990). The five-point Likert-scale ranged from "strongly disagree" (1) to "strongly agree" (5). A higher score indicates higher ease of use. Sample items include: "I think the cosmetic medical service personnel should be attractive in appearance" (α= 0.928).

Financial risk: Financial risk was measured with the inventory developed by Jacoby and Kaplan (1972). The 2-item, 5-point Likert scale ranged from 1 (strongly disagree) to 5 (strongly agree). Sample items include: "The cosmetic medical service I received can be purchased at lower prices", etc. (α= 0.871).

Performance risk: Performance risk was measured by the scale developed by Jacoby and Kaplan (1972). The five-point Likert scale contained one item: "the cosmetic medical service I received is not as good as the service employee claimed" (α=0.901).

Physical risk: Physical risk was measured by the inventory developed by Jacoby and Kaplan (1972). The scale consisted of 2 items measured on a five-point Likert scale. Sample items include "The cosmetic medical service I received may cause damage to my body", etc. (α=0.778)

Psychological risk: Psychological risk was measured by the scale developed by Jacoby and

Kaplan (1972). It was composed of 2 items measured on a five-point Likert scale. Sample items include "The cosmetic medical service I received is not in line with my personal style", etc. (α=0.847).

Social risk: Social risk was measured by the scale developed by Jacoby and Kaplan (1972). It was composed of 2 items measured on a five-point Likert scale. Sample items include "I am afraid that my family and friends do not agree to the cosmetic medical service styles", etc. (α=0.786).

Price Sensitivity: Price sensitivity was measured by a scale developed by Monroe (1973). It consisted of 4 items measured on a five-point Likert scale. Sample items include "In the selection of cosmetic medicine, price is a key factor of consideration", etc. (α=0.812)

The questionnaire was originally prepared in English and then translated into Chinese through the back-translation method (McGorry 2000). The instrument was finalized based on the feedback from a pilot sample of 30 outpatients in the research locations. Specifically, the pilot samples had no difficulty understanding the items in the survey instrument. Therefore, there was no compelling reason to make any changes to the questionnaire.

ANALYSIS

To assess the direct and indirect relationships among physical attractiveness, financial risk, performance risk, physical risk, psychological risk, social risk, and price sensitivity, the scales were subjected to confirmatory factor analysis (CFA) structural equation modeling (SEM) using AMOS 7.0 (Arbuckle 2006) to provide support for the issues of dimensionality, as well as convergent and discriminant validity (Anderson and Gerbing 1988). The measures were also subjected to Cronbach's alpha and Pearson product-moment correlation analyses through SPSS17.0 to provide support for the issues of internal consistency and discriminant validity.

This study employed the nested model approach, as have others using SEM, in order to examine meditational models (e.g., Niehoff and Moorman 1993). In this model, the paths from physical attractiveness, the mediator (financial risk, performance risk, physical risk, psychological risk, and social risk), and price sensitivity were estimated. The hypothesized relationships were measured using AMOS 7.0 through path analysis.

RESULTS

Characteristics of the respondents

Table 1 demonstrates the characteristics of the respondents, as follows: 68.3% of the respondents were female; 50.5% of the respondents were between the ages of 41 and 60; 53.8% had a university degree; 41% reported incomes of under NT$500,001~1,000,000.

Table 1: Characteristics of the respondents (n=366)

	Frequency	Percentage
Gender		
Male	116	31.7
Female	250	68.3
Age (Year)		
Under 20	9	2.5
21-40	121	33.1
41-60	185	50.5
Above 61	51	13.9
Education		
High school	63	17.2
University	197	53.8
Graduated	106	29.0
Occupation		
Civil servants	100	27.3
Healthcare	26	7.1
Business	76	20.8
Housewife	50	13.7
Student	41	11.2
Retiree	40	10.9
others	33	9.0
Monthly pay		
Under NT500,000	89	24.3
500,001-1,000,000	150	41.0
1,000,001-1,500,000	30	8.2
1,500,001-2,000,000	6	1.6
Above 2,000,001	91	24.9

Psychometric properties of the measures

The measures were subjected to a series of CFAs in order to provide support for the issues of dimensionality, and convergent and discriminant validity. In light of the results of the CFA, several items were deleted due to low standardized loadings (<.50), or insignificant

t-values. Deletion of items is widely used for scale purification processes, and similar patterns are observed in other empirical studies (e.g., Netemeyer, Brashear-Alejandro, Boles 2004; Hartline and Ferrell 1996). Table 2 demonstrates that the magnitude of the standardized loadings (ranged 0.643 to 0.961) and all t-values (ranged 2.607 to 17.586) were significant (e.g., CFI=0.899, RMR=0.043). Of the 19 items, 16 items had standardized loadings greater than 0.70. The magnitudes of the loadings, with their significant t-values, provided support for convergent validity (Anderson and Gerbing 1988).

In addition, a series of pairwise CFAs were employed to assess the issue of discriminant validity. In particular, this study first fit a two-dimensional model for each pair of the study constructs, and then we forced the items representing each factor into a single factor solution. Various fit statistics produced better results for a two-factor model. The results strongly suggest that each set of items represents a single underlying construct, which provides evidence for discriminant validity (Anderson and Gerbing 1988). Internal consistency analysis was made by computing the coefficient alpha for each construct. Table 2 shows that almost all Cronbach's alphas are greater than the benchmark of 0.70, as recommended by Nunnally (1978).

Table 2: Scale items, reliabilities, and confirmatory factor analysis results

Scale items	Standardized loadings	t	Alpha
Physical Attractiveness			.9289
I think cosmetic medical service personnel should be attractive in appearance	0.875	11.575	
I think that cosmetic medical service personnel should be fashionable in appearance	0.922	9.248	
I think that cosmetic medical service personnel should be handsome/beautiful	0.937	8.010	
I think that cosmetic medical service personnel should be elegant	0.922	9.438	
I think that cosmetic medical service personnel should be sexy in appearance	0.757	13.359	
Financial Risk			.8717
The price of the cosmetic service I received is too high and is not worth the value	0.877	13.081	
The cosmetic medical service I received can be purchased at lower prices	0.864	11.295	
Performance Risk			.9011
The cosmetic medical service I received is not as good as the service employee claimed	0.833	10.019	
The cosmetic service I received is not in line with my personal needs	0.961	12.607	
Physical risk			.7786
The cosmetic medical service I received may cause damage to my body	0.802	12.449	
I am concerned about the safety of cosmetic medical service	0.754	11.601	
Psychological risk			.8472
The cosmetic medical service I received is not in line with my personal style	0.787	11.222	
The cosmetic service I received is not in line with my status	0.878	7.570	
Social risk			.7865
I am afraid that my family and friends do not agree to the cosmetic medical service styles	0.882	9.359	
I am afraid that my friends and family will laugh at me after receiving cosmetic medical service	0.643	17.586	
Price Sensitivity			.8175
In the selection of cosmetic medicine, price is a key factor of consideration	0.757	11.366	
In the selection of cosmetic medicine, I will compare the price and make special efforts for low prices.	0.811	12.916	
I changed the purchase plan to receive the low price advantages of the cosmetic medicine clinic.	0.851	8.420	
In the selection of cosmetic medicine, I am sensitive to transaction prices.	0.774	12.052	

Correlation analysis results

Composite scores for each construct were computed by averaging the scores across items representing that construct. Table 3 demonstrates that the correlations among the study constructs range from 0.035 (gender and age) to 0.526 (financial risk and performance risk). None of the correlation coefficients was equal to and/or higher than 0.90 (Tabachnick and Fidell 1996), which provided further evidence for discriminant validity. Means and standard deviations of the composite scores are as shown in Table 3.

Table3: Correlation of all variables (N=366)

variables	Mean	SD	1	2	3	4	5	6	7	8	9	10	11
1.Gender	.70	.50	1										
2.Age	48.17	8.76	.035	1									
3.Education	1.78	.45	-.080	.143**	1								
4.Pay	1.74	.95	.203**	.443**	.061	1							
5.physical attractiveness	1.72	.26	.122*	-.326**	.043	-.004	1						
6.financial risk	3.41	.84	188**	.102*	-.059	.081	-.148**	1					
7.performance risk	3.67	.71	.208**	.085	-.010	.113*	-.114*	.526**	1				
8.physical risk	3.62	.78	.220**	-.007	.070	.067	-.116*	.330**	.461**	1			
9.psychological risk	3.63	.66	-.124*	-.064	.044	-.080	-.190**	.114*	.135*	.138*	1		
10.social risk	3.72	.71	-.104*	-.006	.147**	.032	-.113*	158**	.137**	.154*	.418**	1	
11.price sensitivity	3.75	.74	.033	.142**	.167**	.066	-.204**	.107*	.191**	.180**	.109*	.204**	1

Note: Gender was coded as a binary variable (1= male, 2=female). Age was coded (1=under 20 years, 2= 21-40 years, 3=41-60 years, 4=above 61 years). Education was coded (1= under high school, 2=high school, 3=university, 4= master/ Phd). Monthly pay was coded (1=underNT$500,000, 2= NT$ 500,001-100,000, 3=NT$1,000,001-1,500,000, 4= NT$1,500,001-2,000,000, 5 = above NT$2,000,001).

*p<0.05; **p<0.01

Table 3 also demonstrates that three control variables – age and education, have significant correlation with price sensitivity (r=0.142, 0.167, p<0.05). This positive correlation shows that older female consumers with higher education have high price sensitivity. Table 3 also shows that financial risk, performance risk, physical risk, psychological risk, and social risk have significant positive correlations with price sensitivity. These results represented that consumers with higher levels of financial risk, performance risk, physical risk, psychological risk, and social risk would have higher price sensitivity.

Path analysis results

The hypothesized relationships were tested using AMOS 7.0 through path analysis.

Model fit statistics, as shown in Table 4, collectively demonstrate that the research model fits the data well (X^2=43.4, df=10, p=0.000; CFI=0.917, NFI=0.922, GFI=0.909, AGFI=0.901). Results of path analysis show that the 10 hypotheses, as proposed by this study, are supported (as illustrated in Figure 1).
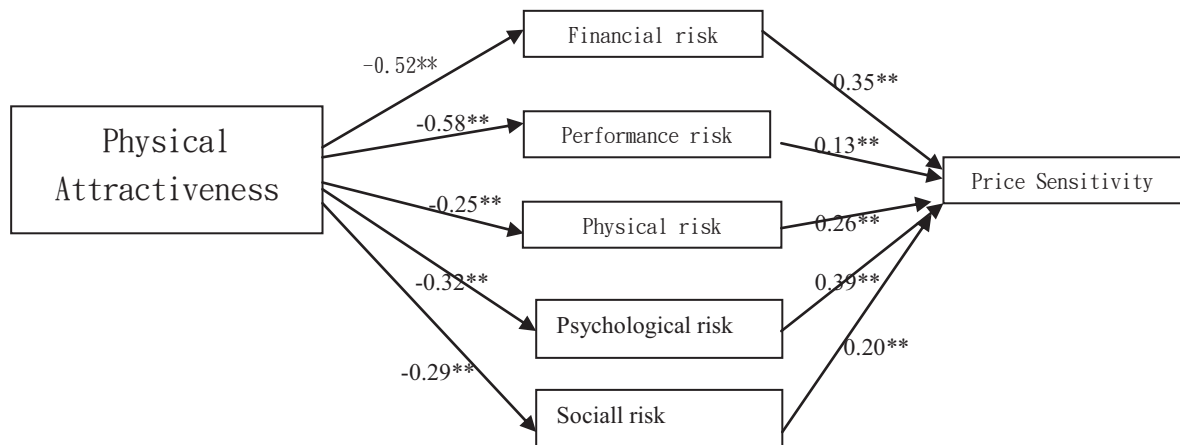
Figure 1: Hypothesized model

Specifically, H1 predicts that physical attractiveness will negatively affect financial risk (β=-.52, p<.05). H2 predicts that physical attractiveness will negatively affect performance risk (β=-.58, p<.05). H3 predicts that physical attractiveness will negatively affect physical risk (β=-.25, p<.05). H4 predicts that physical attractiveness has negative impact on psychological risk (β=-.32, p<.05). H5 predicts that physical attractiveness has negative impact on social risk (β=-.29, p<.05). H6 predicts that financial risk has positive impact on price sensitivity (β=.35, p<.05). H7 predicts that performance risk has positive impact on price sensitivity (β=.13, p<.05). H8 predicts that physical risk has positive impact on price sensitivity (β=.26, p<.05). H9 predicts that psychological risk has positive impact on price sensitivity (β=.39, p<.05). H10 predicts that social risk has positive impact on price sensitivity (β=.20, p<.05). In addition, one of the control variables (age) has a significant positive effect on price sensitivity (β=.109, p<.05).

Table 4: Model test results

Control variables and hypothesized relationships	Standardized parameter estimates	t-Values	Accepted/rejected
Impact on price sensitivity			

Control variable			
Gender	0.038	1.220	N/A
Age	0.109*	2.626	N/A
Education	0.005	0.064	N/A
pay	-0.007	-0.097	N/A
Physical Attractiveness→financial risk	-0.52**	-12.48	H1-accepted
Control variables and hypothesized relationships	Standardized parameter estimates	t-Values	Accepted/rejected
Physical Attractiveness→performance risk	-0.58**	-3.92	H2-accepted
Physical Attractiveness →physcial risk	-0.25**	-4.88	H3-accepted
Physical Attractiveness → psychological risk	-0.32**	-5.69	H4-accepted
Physical Attractivenss → social risk	-0.29**	-5.69	H5-accepted
Financial risk → price sensitivity	0.35**	7.39	H6 accepted
Performance risk → price sensitivity	0.13**	2.88	H7 accepted
Physical risk → price sensitivity	0.26**	5.26	H8 accepted
Psychological risk → price sensitivity	0.39**	8.53	H9 accepted
Social risk → price sensitivity	0.20**	4.32	H10 accepted

R^2=0.035

Fit statistics

X^2=43.4, df=10, p=0.000

CFI=0.917, NFI=0.922, GFI=0.909, AGFI=0.901

RMSEA=0.070

RMR=0.047

Note: *$p<0.05$; **$p<0.01$

DISCUSSION

Research findings show that, physical attractiveness negatively affects financial risk (H1), performance risk (H2), physical risk (H3), psychological risk (H4), and social risk (H5); financial risk (H6), performance risk (H7), physical risk (H8), psychological risk (H9), social risk (10) positively affects price sensitivity.

This study argued that cosmetic medicine is a beauty-related service industry. If the service employee's physical attractiveness is higher, in the face of multiple risks of cosmetic medical service (financial risk, performance risk, physical risk, psychological risk, and social risk), consumers will have a higher professional evaluation, and professional capabilities is an important factor of consumer trust (Swan et al., 1985). If the consumers trust the employee's expertise and professionalism, and recognize the service as safe and reliable, they will be more interested in professional information and cues (Homburg and Stock, 2004), thus, the

risks of cosmetic medical service can be reduced. This viewpoint is in line with the argument of Homburg and Stock (2004), that service employees with high degree professionalism and expertise will display a positive image, and consumers will trust the information and cues provided by them.

In the cosmetic medical service purchase decision-making process, consumers expect to become more beautiful. If cosmetic medical service personnel can allow consumers to learn about the fact that cosmetic medicine is an industry combining medical professional knowledge and beauty care techniques, then the service personnel require relevant professional knowledge and practice licenses, unlike general commodities that attract customers by low price and discounts, and as the consumer perceived risk will be low and the bargaining space little, price sensitivity is naturally low. This is consistent with the argument by Strombom, Buchmuel, Thomas, and Feldstein (2002); as each person will evaluate the risk, it can affect the price flexibility of the purchased goods and commodities.

Meanwhile, this study also found that older consumers, and consumers with a higher educational level, are more sensitive to price. These findings are partially different from the findings of Sirvanci (1993), that price sensitivity is positively correlated to age and negatively correlated to educational level. As cosmetic medicine is regarded as an industry integrating medicine and beauty care, when age and educational degree is higher, people will be more sensitive to medical practices.

MANAGERIAL IMPLICATIONS AND FURTHER STUDY

This study found that the cosmetic medical service personnel of higher degree of physical attractiveness have a significant impact on subject perceived risk. During the consumption process, perceived risk will affect consumer intention (Mitra et al.,1999)。 If perceived risk is higher, the purchase intention can be more easily hindered (Garretson and Clow, 1999), which can also increase price sensitivity. Therefore, it is recommended that service employee's appearance and composure should also be listed as assessment items in the selection of service employees. Regarding employee training, the improvement of physical attractiveness should be categorized as a training item, or appearance should be included as an item of performance evaluation to enhance the positive impact of service employees on consumers. In addition, as cosmetic medicine is a highly professional service, the industry should more proactively encourage employees to improve educational degrees and experience, in order that consumers may have a better positive assessment of the service employees. If the service employee's professional capabilities are higher, it can enhance the positive evaluation of the consumers, meaning they may perceive the high professionalism of the service, and thus, have low space for price bargaining. Price sensitivity has not been reduced due to this reason. In this case, if the industry can provide high quality service and care after treatment, it can enhance repurchase intentions and consumption frequency.

Regarding the research samples, this study selected consumers with cosmetic medical experience as the sampling subject. Female subjects are more concerned with physical attractiveness, as compared to male subjects. As a result, the proportion of male and female subjects is not even to cause bias. It is suggested that future studies of male and female consumers can be conducted separately.

Regarding the research method, the methods of data collection and analysis can be divided into qualitative and quantitative methods. This study used the quantitative method of questionnaire survey to verify the hypotheses of this study, thus, the sampling was not prudent. It is suggested that more in-depth interviews can be conducted in the future to obtain richer findings.

REFERENCES

1. Addis, F. S. & Myers, C. (2012). Brand Identity: The Power of First Impressions. Rough Notes, 155(4), 88-90.
2. Anderson, J. C. & Gerbing, D. W. (1988). 'Structural equation modeling in practice: a review and recommended two-step approach', *Psychological Bulletin*, 103, 411-23.
3. Arbuckle, J. L. (2006). Amos (Version 7.0) [Computer software], Chicago, *SPSS*.
4. Baird, I. S. & Thomas, H. (1985). Toward a Contingency Model of Strategic Risk Taking. The Academy of Management Review, 10(2), 230.
5. Baker, M. J. & Churchill, A.G. Jr. (1977). The impact of physically   attractive   models on advertising evaluations. *Journal of   Marketing   Research, 14*(4), 538-555.
6. Bauer, R. A. (1960). Consumer behavior as risk taking. Harvard Business Press, 23-30.
7. Bellenger, D. N., Robertson, D. H. & Hirschman, E. C. (1978). Impulse Buying Varies by Product. Journal of Advertising Research, 18(6), 15.
8. Berry, L. L. (1980). Services Marketing Is Different. Business, 30, 3, 24.
9. Bitner, M. J. (1992). Service scapes: The impact of physical surrounding on customers and employees. *Journal of Marketing,*   56(4), 57-71.
10. Bower, A. B. & Ladreth, S. (2001). Is beauty best? Highly versus normally attractive models in advertising. *Journal of Advertising*, 30, 1-12.
11. Burns, G. L. & Farina, A. (1987). Physical attractiveness and self-perception of mental disorder. *Journal of Abnormal Psychology*, 96(2), 161-163.
12. Campbell, M. C. & Goodstein, R. C. (2001). The moderating effect of   perceived on consumers' evaluations of product incongruity:Perference for the norm. *Journal of Consumer Research*, 28(3), 439-450.
13. Caballero, M. J. & Solomon, P. J. (1984). Effects of model attractiveness sales on sales response. *Journal of Advertising*, 13, 17-23.
14. Chaudhuri, A. (1998). Product Class Effects on Perceived Risk: The Role of Emotion. International Journal of Research in Marketing, 15(2), 157-168.
15. Cox, D. F. (1967). Risk Taking and Information Handing in Consumer   Behavior - An Intensive Study of Two Cases. Harvard University Press, 34-81.

16. Danus, F. D. & Lindsey-Mullikin, F. (2012). Expected product price as a function of factors of price sensitivity. Journal of Product & Brand Management, 21(4), 293-300.

17. Dion, K. K. (1972). Physical attrativeness and evaluation of children's transgressions. Journal of Personality and Social Psychology, 24,(2), 207-213.

18. Dowling, G. R. (1986). Perceived Risk: The Concept and its measurement. *Psychology and Marketing*, 3(Fall), 193-210.

19. Dowling, G. R. & Staelin, R. (1994). A model of and intended risk-handling activity. *Journal of Consumer Research,* 21(1), 119-134.

20. Eastwick, P. W.,Eagly, A. H.,Finkel,E. J. Johnson,S. E. (Nov 2011). Implicit an dexplicit preferences ofr physical attractiveness in a romantic partner: A double dissociation in predictive validity. Journal of Personality and Social Psychology, 101(5), 993-1011.

21. Erdem, T., Swait, J. & Louviere, J. (2002). The impact of brand credibility on consumer price sensitivity. Intenational Journal of Research in Marketing, 19(1), 1-19.

22. Estelami, H. & De Maeyer, P. (2004). Product category deteminants of price knowledge for durable consumer goods. Journal of Retailing, 80(2), 129-137.

23. Ferguson, L. (2012). Gaining (From) Your Clients Trust. Journal of Accountancy, 213(5), 38-40.

24. Garretson, J. A. & Clow, K. E. (1999). The influence of coupon face value on service quality expectations, risk perceptions and purchase intentions in the dental industry. The Journal of Services Marketing, 13(1), 59-72.

25. Greitemeyer, T. & Kunz, I. (2013). Name-Valence and Physical Attractiveness in Facebook: Their Compensatory Effects on Friendship Acceptance. The Journal of Social Psychology, 153(3), 257.

26. Grossbart, T. A. & Sarwer, D. B. (1999). Cosmetics surgery: Surgical tools - psychosocial goals. *Seminars in Custneous Medicine and Surgery*, 18(2), 101-111.

27. Han, S., Gupta, S., & Lehmann, D. R. (2001). Consumer price sensitivity and price thresholds. Journal of Retailing, 77(4), 435-456.

28. Hartline, M. D. & Ferrell, O. C. (1996). The management of customer-contact service employees: an empirical investigation. *Journal of Marketing*, 60, 52-70.

29. Hatfied, E. & Sprecher, S. (1986). Mirror, Mirror: The Importance of Looks in Everyday Life. Albany, N. Y.: State university of New York.

30. Homburg, C. & Stock, R. M. (2004). The Link Between Salespeople's Job Satisfaction and Customer Satisfaction in a Business-to-Business Context: A Dyadic Analysis. Academy of Marketing Science, 32(3), 144-158.

31. Jacoby, J. & Kaplan, B. (1972). The Components of Perceived Risk,*Association for Consumer Research*, 382-386.

32. Kahle, L. R. & Homer, P. M. (1985). Physical Attractiveness of the Celebrity Endorser: A Social Adaptation Perspective. *Journal of Consumer Research,* 11 (March), 954-961.

33. Kamins, M. A. (1990). An investigation into the " match-up" hypothesis in celebrity advertising: When beauty may be only skin deep. *Journal of Advertising*, 4-13.

34. Kim, B. D., Srinivasan, K. & Wilcox, R. T. (1999). Identifying price sensitive consumers: The relative merits of demographic vs. purchase pattern information. Journal of Retailing, 75(2), 173-193.

35. Koerning, S. K. & Page, A. L. (2002). What if your dentist looked   like Tom Cruise? Applying the match-up hypothesis to a service   encounter. *Psychology & Marketing*, 91-110.

36. Krishnamurthi, L. & Papatla, P. (2003). Accounting for heterogeneity and dynamics in the loyalty-price sensitivity relationship. Journal of Retailing, 79(2), 121-135.

37. Lee, Y. C., Wu, W. L., Lin, Y. C. & Lee, C. K. (2014). The Effect of Word-of-Mouth, Knowledge, and Promotions on Purchase Intention of Medical Cosmetics. Internaitonal Journal of Organizational Innovation (Online), 6(3), 96-105.

38. Lovelock, C. & Wright, L. (1999). Principles of service marketing and mamagement. Englewood Cliffs, NY: Prentice Hall.

39. McGorry, S. Y. (2000). Measurement in a cross-cultural environment: survey translation issues. *Qualitative Market Research: An International Journal* , Vol.3 No. 2, pp.74-81.

40. Mcknight, D. H., Choudhury, V. & Kacmar, C. (2002). Developing and validating trust measures for e-commerce: An integrative typology. Information Systems Research, 13, 334-359.

41. Mitra, K., Reiss, M. C. & Capella, L. M. (1999). An Examination of   Perceived   Risk, Information Search and Behavioral Intentions in   Search,   Experience   and   Credence Services. *The Journal of   Services Marketing, 13*(3), 208-228.

42. Monroe, K. B. (1973). Buyers 'subjective perceptions of price.*Journal of Marketing Research in Consumer Behavior,* 10, 70-80.

43. Morrow, P. C. (1990). Physical attractiveness and selection decision making. *Journal of Management*, 16, 45-60.

44. Netemeyer, R. G., Brashear-Alejandro, T. & Boles, J. S. (2004). A cross-national model of job-related outcomes of work role and family role variables: a retail sales context. *Journal of the Academy of Marketing Science*, .32(1), pp.49-60.

45. Niehoff, B. P. & Moorman, R. H. (1993). Justice as a mediator of the relationship between methods of monitoring and organizational citizenship behavior. *Academy of Management Journal,* 36, 527-56.

46. Nunnally, J. C. (1978). *Psychometric theory* (2ⁿᵈ ed), New York, McGraw-Hill.

47. Ohanian, R. (1990). Construction and Validation of a Scale to Measure Celebrity Endorsers' Perceived Expertise, Trustworthiness,   and   Attractiveness.*Journal of Advertising, 19*(3), 39-52.

48. Ohanian, R. (1991). The impact of celebrity   spokespersons'perceived image on consumers'intention to purchase. *Journal of Advertising   Research, 31*(1), 46-54.

51. Parekh, H. & Kanekar, S. (1994). The physicall attractiveness stereotype in a consumer-related situation. The Journal of Social Psychology, 134(3), 297-300

52. Patzer, G. L. (1983). Source credibility as a function of communicator physical. attractiveness. *Journal of Business Research*, 11, 229-241.

53. Patzer, G. (Jan 2011). Ethics concerning physical attractiveness phenomenon: business strategy versus research knowledge. Journal of Academic and Business Ethics, 3(1), 13.

54. Patzer, G. (Feb 2013). Physical attractiveness: uncertainty of the presemptive causal direction. Journal of Management and Marketing Research, 12, 1-9.

55. Peter, J. P. & Tarpey, L. X. (1975). A comparative analysis of three   consumer decision strategies. *Journal of Consumer Research*, *2*,   29-36.

56. Peter, J. P. & Olson, J. C(1990). Consumer Behavior and Marketing   Strategy. Illinois: Richard D Irwin Inc, 5-6.

57. Petroshius, S. M. & Crocker, K. E. (1989). An Empirical Analysis of Spokesperson Characteristics on Advertisement and Product Evaluations. Academy of Marketing Science,17(3), 217.

58. Podsakoff, P. M. & Organ, D. W. (1986). Self-reports in organizational research: Problems and prospects. *Journal of Management,* 12(4), 531-44.

59. Puri, R. (1996). Measuring and Modifying Consumer Impulsiveness: A   Cost-Benefit Accessibility Framework. *Journal of Cosumer   Psychology*, *5*(2), 87-113.

60. Ramirez & Goldsmith (2009). Some Antecedents of Price Sensitivity. Journal of Marketing Theory and Practice, 17, 3, 199-213.

61. Reingen, P. H., Gresham, L. G. & Kernan, J. B. (1980). Behavioral   Consequences of the Physical Attractieness Stereotype in   Personal Selling. In R. Bagozzi (Ed.), *Marketing in the 80's: Changes & Challenges*, 109-113. Chicago, IL: American   marketing Association.

62. Riggo, R. E., Widaman, K. F., Tucker, J. S. & Salinas, C. (1991). Beauty   is more than skin deep: Component of attractiveness. *Basic and   Applied Social Psychology, 12*(4), 423-439.

63. Sirvanci M. B. (1993). An Empirical Study of Price Thresholds and   Price   Sensitivity. *Journal of Applied Business Research*, *9* (2), 43-49.

64. Solnick, S. J. & Schweitzer, M. E. (1999). The influence of   physical   attractiveness and gender on ultimatum game decisions. *Organizational behavior and human decision processes, 79*(3),   199-215.

65. Stokes, R. & Frederick, R. C. (2003). Women's perceived body images: relations with personal happiness. *Journal of   Women Aging*, *15*(1), 17-29.

66. Strombom, B. A., Buchmuel, T., Thomas C. & Feldstein, P. J. (2002). Switching Cost, Price Sensitivity and Health Plan Choice. Journal of Health Economics, 21(1), 89-116.

67. Swan, J.E., Trawick, I.F. & Silva, D.W. (1985).   How industrial   sale people gain customer trust. *Industrial Marketing Management*, *14* (3), 203-211.

68. Wakefield, K. L. & Inman, J. J. (2003). Situational price sensitivity: the   role   of consumption occasion, social context and income. *Journal of Retailing, 79* (4), 199-212.

69. Zeithaml, V. A. (1982). Consumer Response to In- Store Price   Information Environment. *Journal of Consumer Research*, *8*(4), 357-369.

A PRELIMINARY STUDY OF PATENT QUALITY IN TAIWAN

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ABSTRACT

Nowadays, the widely used methods for measurements of patents are mainly based on the method of patent citation analysis, in combination with Bibliographic Data. The patent citation analysis conducts different weights and mathematical calculations proposed by different research institutions and organizations.
This study discussed two issues as described below.

1. *In reference to various existing indicators, this study constructs drafting indicators for applications of patent in early days, and extracts information of patents issued by famous domestic and international research institutions for validation.*

2. *This study views the constructed drafting indicators of patents as the output variables, and various indicators of the financial statements of domestic and international listed and OTC companies as the input items. The goal is to conducts performance analysis on the R&D inputs and the output of the quality of patents. This study takes into account the information of existing patent indicators deduced from numerous literatures and empirical studies. In short, this study will precede the data validation based on patent information of both the domestic and international famous research institutions and enterprises with excellent performance.*

INTRODUCTION

In recent years, high technologies have greatly emerging and rapid innovation and development have become core issues for these new emerging industries. Following this international trend, R&D (Research and Development, R&D) has been one of most significant sources for enterprises to improve their competitiveness (Hamel and Prahalad, 1994). Based on the resource-based theory, the competitive advantages of companies originate from the heterogeneous resources. The heterogeneous resource held by the enterprises determines the heterogeneity of enterprises. (Wernerfelt, 1984). Those valuable, rare, hard-to-imitate and irreplaceable heterogeneous resources empower enterprises with sustainable competitive advantages (Barney, 1991). Therefore, the reasons why enterprises focused on R&D and technological innovation are to obtain valuable intangible assets, which are called as a strategic asset by Amit and Schoemaker (1993) in pursuit of long-term competitive advantage of enterprises and are expected to bring maximum economic returns for enterprises.

The market, defined by traditional capitalism is mainly dominated by tangible resources and the exchange and communication of currency and goods. However, with the advent of the knowledge economy era brought by the advances of information technology, the mainstream of market values is converted to the possession of technology, knowledge, patents and other intangible assets. In terms of intangible assets, especially the innovative ideas and concepts, directly affect the enterprises. Whether these affected enterprises could be adapted to the changes, adjusted and could grab new opportunities in rapidly changing business environment or not, the patents become an important intangible asset to demonstrate its innovative ideas and abilities in obtaining legal protections and an important indicator to measure the abilities of technology innovation. Since the end of 1970s, the patents, used as the indicator to measure the output level of technology innovation of enterprises, have been widely used (Griliches, 1984). Grindley and Teece (1997) suggested that in high-tech industry, the patents are seen as a key to getting the competitiveness of enterprises.

Under the trend of the protection of international trade, the competition of enterprises in the market has been transformed into a legitimate weapon in excluding competitors with the assistance of intellectual property as a lawsuit - making international competition as a normal behaviour. In 2011, Central Bank in Taiwan has spent approximately 5.8 billion USD (about NT $ 171 billion) on overseas intellectual property, up 18% than that of 2010. However, the income from overseas intellectual property is approximately USD$ 750 million (NT $ 22.1 billion NT). This fact reflects that the level of royalties on intellectual property

out of business revenues has been promoted gradually.

Taiwan possesses a large amount of U.S. patents, but lack of core and important ones. In the era of rapidly developing knowledge economy, possessing core technique is essential of high-tech industry competition. Once enterprises invented new or better techniques, the old ones will be washed out. The enterprises that initiate innovations will probably replace the original enterprises and become new monopolist (Phillips, 2006). Therefore, in the future market, the strategy of flexible utilization of intellectual property rights is much more important than possessing sophisticated technology. R&D capacity is the most important source for enterprises to improve their competitiveness (Hamel and Prahalad, 1994). Enterprises adopt Internal R&D resources and external technology transfer to acquire technologies. In the process of R&D, the accumulated and developed innovation experience and capabilities of R&D and the intangible assets created by R&D activities are equipped with the feature of heterogeneity that could help enterprises obtain excess returns (Grant, 1991).

Many factors will affect the willingness of enterprise in implementing their R&D plans and thus affect the companies' R&D output, such as patents. Nevertheless, the quality of patents affects their firm values. Therefore, in recent years, many patent analyses are practiced to measure the quality of patents. In the past, researchers have constructed many patent indicators, however, most of which are lagging indicators because they followed up the certified patents only. The evaluative indicators of certified patents are not able to offer real and effective references for the quality of patents in the early days of the application of patents.

Nowadays, the widely used methods for measurements of patents are mainly based on the method of patent citation analysis, in combination with Bibliographic Data. The patent citation analysis conducts different weights and mathematical calculations proposed by different research institutions and organizations.

This study discussed two issues as described below.
1. In reference to various existing indicators, this study constructs drafting indicators for applications of patent in early days, and extracts information of patents issued by famous domestic and international research institutions for validation.
2. This study views the constructed drafting indicators of patents as the output variables, and various indicators of the financial statements of domestic and international listed and OTC companies as the input items. The goal is to conducts performance analysis on the R&D

inputs and the output of the quality of patents. This study takes into account the information of existing patent indicators deduced from numerous literatures and empirical studies. In short, this study will precede the data validation based on patent information of both the domestic and international famous research institutions and enterprises with excellent performance.

LITERATURE REVIEW

This study lays emphasis on the factors of investment in implementations of innovative activities and the performance of the patent outputs. From the perspectives of definitions and the R&D process, this study found that research and innovative activities are good ways in promoting enterprise values. Therefore, using patents as the output variable of R&D and innovation activities, it is necessary to conduct better management and comprehensive strategic planning. The quality of patents is the hottest topic for discussion in recent years. Yen-Pong Jou (2006) pointed out that patent quality is a prerequisite of patent values, and that patent value is the practice of the patent quality. How to track or even guarantee that these patents are equipped with a certain degree of quality before being certified and bring values for enterprises? Thus, this study adopts the analysis of patent indicators and expected to construct a set of methods in order to manage patent quality.

BENEFITS OF R&D

R&D is of critical condition for sustainable development of enterprises (Dosi, 1988) and also the most important source for enterprises to improve their competitiveness (Hamel and Prahalad, 1994). From the perspective of the nature of R&D, Myers (1977) pointed out that R&D is an important value-added activity; the value of the enterprises is composed by the current assets and future growth opportunities of the enterprises; and R&D could bring growth opportunities as well as surpassing capacities in generating profit for the companies. Griliches (1981) used 157 US enterprises as samples to process one study and firstly and explicitly indicated that R&D investment and the acquisition of patents can enhance the value of enterprises. The study of Chan et al (1995) also showed that when high-tech companies announce the increase of investment in the aspects of R&D, their stock price will have positive reactions in the stock market. While defining the R&D processes, Kelm (1995) also suggested that any of the stages may affect the relationship between R&D and reaction of stock market. In addition, a significant number of literatures have supported this conclusion, such as Hall (1993) from Harvard, Levin et al (1987) from Yale and Bloom and Reenen (2002) from UK. These scholars all suggested that patents, as the R&D investment of innovative

activities, reflect technological updates of the companies, and can indeed have valuable contributions for enterprises. Eberhart et al (2008) further found that in comparison with those enterprises who announce to increase the budget for R&D, those enterprises who have already increased the investment can truly bring excessive benefits for shareholders. Based on a comprehensive literature review, this study proposes that R&D investment and the acquisition of patents have positive influence on the value of enterprises.

INPUT OF R&D AND OUTPUT OF PATENTS

R&D can be divided into "input" and "output." Input refers to the invested funds, manpower, equipment and other resources for R&D and output refers to outcomes of R&D, such as products, technologies, patents, and the like. With the advances in information technology and the improvement in the level of industrialization, the investment of enterprises in R&D activities has been gradually increased. The ultimate goal of increasing R&D investment is to develop new products, improve products, improve processes and reduce production costs in order to enhance enterprise competitiveness in the market.

Compared with other indicators, the saying that economists believe that patents can better measure innovation output is well upraised. However, not all innovations can apply for patents or pass verification and certifications. Different quality of patent will also result in its distinctive and dramatic economic returns. However, because patent is equipped with the feature that its descriptive documents should be put into public, it becomes very easy the public to acquire information of patents with the rapid development and construction of electronic database; all of these developments are closely related to R&D and innovative activities. Furthermore, its standardization, objectiveness and frequent updates of regulations have made patenting system a reliable indicator for measuring innovative activities, as well as an alternative way in measuring the contribution of the innovative activities to productivity of enterprises (Griliches, 1990; Acs, Anselinb and Varga).

Kondo (1995) studied the relationship between R&D expenditure and patent output and pointed out that R&D investment plays a significant role in patent output. However, Kondo's study missed the explicit explanation about the fact that: whether the content of the patent output is an exact quantity or the factors of patent quality included. Gayle (2001) considered that the patent includes many unimportant innovations that cannot reveal the authentic level of innovation. Therefore, instead of observing the quantity of the patents, observation of patent quality is an improvement in the aspect of measurement of innovation output. Later, Bloom and Reenen (2002) have conducted research on 200 major industrial manufacturers in

UK and found the owing of the patents which are cited widely can effectively improve the enterprise value.

In other words, only the patents with relatively higher quality could generate values for enterprises. In any case and any stage, the investment on R&D and patent rights of enterprises will affect the values of enterprises; it is the "indirect effects" of the investment on R&D and patent rights of enterprises towards the profits of enterprises. In addition, there are "direct effects" of the investment on R&D and patent rights of enterprises on the value of enterprises, which equals to the benefits of R&D and patent rights and has not been reflected on the profitability. However, it is obvious that these benefits will hereafter have direct impact on the expectation of the market towards the value of enterprises (Sougiannis, 1994).

As the valuable achievements of the R&D and innovation activities, the patents' output has significantly reduced the uncertainty percentage of R&D and innovative activities. Patents mark that the innovation activities are put into practice from the stage of R&D. In other words, patent is a variable generated by the R&D and innovation activities. The increase of the value of enterprises and the improvement of performance are the real output of innovation in terms of economy. Xin Xu and Qing-Guan Tang (2010) pointed out that investment in research and innovation can enhance enterprise value and operating performance and also bring profits and benefits for enterprises. The patenting system, as a motive mechanism, not only guarantees that the contribution of the pioneer R&D and innovation can be awarded, but also receives sufficient investment for its subsequent R&D and innovation (Scotchmer, Suzanne, 2005).

Cuddington and Moss (2001) pointed out that while measuring of the input of R&D and innovation and output of performance, enterprises normally adopt R&D expenses (investment funds) as well as the number of scientists and engineers engaged in research (manpower involved) as input indicators; patent as the similar indicator for the output of innovation. However, as the output indicator of innovation, patent has its natural limitations; that is because the tendency towards different industries, different area and different stages are all different (Griliches, 1990). For different industries and enterprises, whether to adopt the strategies of patents or business secretes in order to protect innovation achievements, the enterprises will need to take into account which one could effectively prevent competitors from imitation and which one could generate higher level of benefits. In next section, this study will sort them out from the outline of regulations to the valuable topics for discussion based on the features of patents.

Ernst (2003) also considered that the patent is one of the most important tools for modern business management and that is also the physical interface between technologies and the laws. Therefore, the quantity of patents possessed by one company is an important indicator for the technological strengths of the enterprise. At the same time, in some ways, patents are always connected with a certain degree of monopoly marketing powers. At present, many high-tech enterprises, both at home and abroad, possess a large quantity of patents. However, is the large quantity enough? For successful enterprises, they have good patent management systems, appropriate R&D and Planning to maximize their profits and returns. Rivette and Kline (2000) pointed out that with the assistance of licensing, cooperation, strategic alliance, litigation and cross-licensing, even using patents as defense, enterprises are able to generate considerable returns. By then, another problem arises, what types of patent could make the above-mentioned statement possible? In next section, we will discuss on the issue of the quality and values of the patents.

VALUES AND QUALITY OF PATENTS

Patent Analysis is a systematic method to arrange patent information. Through searching and researching patent information, people can make statistics, analysis and comparison among the items involved in patent documentations and the content of technique of different cases. Under the assistance of the expertise' knowledge, subject analytic is conducted and is expected to be used widely in the fields of nations, technology, industrial departments and companies (Xie Minghua, 1996, Pavitt, 1988). Hall and Hausman noted that patent analysis is not only an effective tool for planning of technologies and R&D and the management for intellectual properties, but also can be used as the judgmental basis for analysis of the technological competition, the analysis of technological tendency and scope (1986) . At the same time, patents are capable of protecting the achievements of R&D. Whether to adopt patents or business secretes to protect innovation achievements, enterprises will have to consider which one could effectively prevent competitors from imitation and which one could generate higher level of benefits (Anthony and Isabelle, 1998). Neverthelss, most of the research institutes and enterprises tend to publish their research achievements in the form of patents.

Patents provide abundant information of technological innovations. With the help of the information disclosed by patents, we can get access to the technical information of competitors. Therefore, the appropriate utilization of patent information could effectively shorten the expenses and time of R&D and help enterprises effectively manage the allocation of the resources for R&D (Narin, 1995 , Ernst, 1998). Therefore, patent analysis aims at the

source of competitive technological information. Patent analysis is one of the analytic methods frequently adopted by enterprises for their strategies manipulation and competition analysis; patenting is also an intelligence analysis method for enterprises to acquire the competitive advantages over competitors.

RESEARCH DESIGN AND IMPLEMENTATION

This study will consider plenty of literatures and current empirical patent indicators, and then use patents which filed by worldwide well-known research institutions and enterprises that have outstanding performance on patent granted to do the verification. Selected research institutions refer to table 1, enterprises refer to table 2.

Table 1 Selected research institutions

Foreign research institutions		
Nation	**Initials**	**Full name**
Japan	AIST	Advanced Industrial Science Technology
Australia	CSIRO	Commonwealth Scientific Industrial Research Organisation
German	Fraunhofer	Fraunhofer
Canada	NRC	National Research Council
United State	SRI	Stanford Research Institute
Netherland	TNO	Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek
South Korea	ETRI	Electronics Telecommunications Research Institute
Domestic research institutions		
Nation	**Initials**	**Full name**
Taiwan	ITRI	Industrial Technology Research Institute
Taiwan	III	Institute Information Industry

Table 2: Selected enterprises

Rank	Granted	Assignee Name	Nation
1	6478	International Business Machines	United State
2	5081	Samsung Electronics Co Ltd KR	South Korea
3	3174	Canon K K JP	Japan
4	3032	Sony Corp JP	Japan

Rank	Granted	Assignee Name	Nation
5	2769	Panasonic Corp JP	Japan
6	2613	Microsoft Corp	United State
7	2447	Toshiba Corp JP	Japan
8	2013	Hon Hai Precision Industry Co Ltd TW	Taiwan
9	1652	General Electric Co	United State
10	1624	LG Electronics Inc KR	South Korea
48	650	Taiwan Semiconductor Manufacturing Co TW	Taiwan

Source: IFI CLAIMS® 2012 Top US Patent Assignees

Table3: Main strategic and value application of patent analysis

Applications	Enterprises' strategies	Value
Technology competition analysis	Compare enterprises with their patent portfolio and strategies, identify the growth and decline of competitor's technologies	Improve product management strategy and decision-making, early control of the prospective technology
Risk assessment	Evaluate potential patent technologies, analyze the risk of cooperative development opportunities	Trade patents more efficient, reduce the uncertainty and risk of investment and decision-making
Patent portfolio management	Confirm valuable patents and products, as well as their potential market	Increase the return of patents (through authorization, trading or developing), early detect the potential market of substitutes
R&D management	Plan and assess the target technologies and products, seek leading technologies	Improve the efficiency of R&D, improve the sense of invention
Products field monitoring	Review the contents of new patent and its ownership, infringement confirmation	Early detect potential impact, more proper maintenance of intellectual property rights

Source: literature arrangement

This research will collect and arrange literatures to conclude the patent indicators which can be used to apply for early evaluation of patent quality, then using multiple regression analysis to verify whether these indicators are representative or not. Also by means of analyzing actual patent information objectively to discuss whether these indicators can accurately reflect patent drafting quality. Based on above mentioned process, this research will conclude which

indicators could actually represent patent drafting quality. Furthermore, patents, as an important output of enterprises' R&D activities, in order to measure the performance in reality that enterprises' R&D output patent, this research is going to use data envelopment analysis method (DEA) to measure domestic enterprises' R&D performance, in order to understand domestic enterprises not only generally attaches great importance to R&D but also patent quality at the same time.

SAMPLE DATA

A patent takes about five years from publishing to be cited, of which about 70% of the patent document is not cited or referenced only once or twice. Furthermore, be cited six times, or a higher number of patent only accounts for about 10% (Narin and Olivastro, 1998). Hence, this research is going to search all the granted patents in 2001 to 2004 and sort by the number of cited in different UPC (United States Patent Classification) code, then pick out top 10% as high quality patents. Therefore, according to the reason that for the most part of Taiwan's industries are located in IPC code (International Patent Classification) G and H category, so this research will narrow into these two classes in order to adjoin real industrial situation in Taiwan.

RESEARCH CONTENTS

This research will collect and arrange literatures to conclude the patent indicators which can be used to apply for early evaluation of patent quality, then using multiple regression analysis to verify whether these indicators are representative or not. Also by means of analyzing actual patent information objectively to discuss whether these indicators can accurately reflect patent drafting quality. Based on above mentioned process, this research will conclude which indicators could actually represent patent drafting quality and set criteria.

```
┌─────────────────────────┐        ┌─────────────────────────┐
│ Search the patents belong│ - - -> │ Choose the domestic and  │
│ to IPC class G (physical)│        │ foreign well-known       │
│ and H (electrical)       │        │ research institutions'   │
│                          │        │ and enterprises' patents │
└─────────────────────────┘        └─────────────────────────┘
```

Sort by commonly seen patent indicators, capture high quality, medium and low quality patent group

According to the selected domestic and foreign well-known research institutions and enterprise patent group, by means of statistical analysis to conclude

According to the selected patent group, by means of statistical analysis and cross-comparison to provide advices criteria of patent drafting

Compare index value

Adjust

Construction of patent drafting indicators

Fig X: Research structure

A patent takes about five years from publishing to be cited, of which about 70% of the patent document is not cited or referenced only once or twice. Furthermore, be cited six times, or a higher number of patent only accounts for about 10% (Narin and Olivastro, 1998). Hence, this research is going to search all the granted patents in 2001 to 2004 and sort by the number of cited in different UPC (United States Patent Classification) code, then pick out top 10% as high quality patents, 45% to 55% as normal quality patents and the lowest 10% as low quality patents. Therefore, according to the reason that for the most part of Taiwan's industries are located in IPC code (International Patent Classification) class G and class H, so this research will narrow into these two classes in order to adjoin real industrial situation in Taiwan.

To construct and verify the patent drafting indicators in the early stage of patent applying, we arrange plenty of literatures and figure out current empirical patent indicators then conclude the patent drafting indicators which include the number of claim, the number of independent,

the number of citing patent and the number of filing country, as well as the dependent will be TileRate which represent patent quality. The following table shows detailed definition of the indicators above.

Table X: The operational definition of variables

Patent drafting indicators	
Variable	**Definition**
Claim Count	The number of claim when applying patent
Independent Claim Count	The number of independent when applying patent
Citing Prior Patent Count	The number of citing patent when applying patent
Filing Country Count	The number of filing country when applying patent
Patent quality indicator	
TileRate	The percentile sort by the number of cited in different UPC

Following patent quality indicator TileRate set by this research, former 10% samples have been screened and selected as good quality samples. There are 18,469 patents in group G and 16,307 in group H.

From literature review, it can be summarized at the first stage that patent quality has been closely affected by claim count, independent claim count, citing prior patent count and filing country count. However, the correction and their related linkage still need further rectified by regression test. The hypothesis of this study has considered that the above four patent quality indicator can affect each other. In order to test this hypothesis, multiple regression test will be used to analyze these samples.

Table X: Multivariate regression test results with the G category patent

Claim Count	Filing Country Count	Citing Prior Patent Count	Independent Claim Count	Linear Model	Goodness-of-fit
V	V	V	V	Non-Significant	
V	V	V		Non-Significant	
V	V		V	Non-Significant	
V		V	V	Significant	0.023
	V	V	V	Significant	0.020
V	V			Non-Significant	

Claim Count	Filing Country Count	Citing Prior Patent Count	Independent Claim Count	Linear Model	Goodness-of-fit
V		V		Significant	0.019
V			V	Significant	0.014
	V	V		Significant	0.016
	V		V	Significant	0.011
		V	V	Significant	0.019
V				Significant	0.006
	V			Significant	0.001
		V		Significant	0.015
			V	Significant	0.009
P.S: Checked item is selected as variable, all dependent variable is patent quality (TileRate)					

Table X: Multivariate regression test results with the H category patent

Claim Count	Filing Country Count	Citing Prior Patent Count	Independent Claim Count	Linear Model	Goodness-of-fit
V	V	V	V	Non-Significant	
V	V	V		Non-Significant	
V	V		V	Non-Significant	
V		V	V	Significant	0.018
	V	V	V	Significant	0.014
V	V			Non-Significant	
V		V		Significant	0.014
V			V	Significant	0.013
	V	V		Significant	0.009
	V		V	Significant	0.009
		V	V	Significant	0.014
V				Significant	0.007
	V			Significant	0.001
		V		Significant	0.009
			V	Significant	0.008
P.S: Checked item is selected as variable, all dependent variable is patent quality (TileRate)					

From sample analysis of original sample groups, it can be found that there are big standard deviation among them for several extreme statistic figures in there. Thus, it is needed to conduct secondary adjustment. In this regard, this research adopts expert judgment. Ruling out some extreme data, good sample patent quality such as group 10 and 11 has been integrated into statement statistic.

Table X: Assumed criterion value based on the average of each indicators

G Category Patents				
	Claim Count	**Filing Country Count**	**Citing Prior Patent Count**	**Independent Claim Count**
Assumed criterion value	24.16	3.74	13.66	3.81
H Category Patents				
Assumed criterion value	21.27	3.50	15.75	4.04

There are two stages in this testifying stage. At the first stage, it is examined through national and outside national organization. At the secondary stage, it is examined through famous international entrepreneur. In this research, former 10% good patent quality that was chosed between 2001 to 2004.   The patent performance of these patent groups is as followings.

Table X: The patent performance of well-known research institutes

G Category Patents					
	Claim Count	**Filing Country Count**	**Citing Prior Patent Count**	**Patent Count**	**Independent Claim Count**
Average of selected research institutes	23.1	4.92	6.52	61	3.28
H Category Patents					
	Claim Count	**Filing Country Count**	**Citing Prior Patent Count**	**Patent Count**	**Independent Claim Count t**
Average of selected research institutes	20.8	3.94	4.88	83	3.17

At this stage, good patent quality samples selected by this study and good patent quality

samples selected by famous institutes have been conducted for T-test. The outcome of T-test has shown that writing indicator of good patent quality selected by this research could provide with characteristic which could be applied to general industries.

Table X: T-test result with selected famous research institutes

G Category Patents				
	Claim Count	**Filing Country Count**	**Citing Prior Patent Count**	**Independent Claim Count**
With selected research institutes	Non-Significant	Non-Significant	Non-Significant	Non-Significant
H Category Patents				
	Claim Count	**Filing Country Count**	**Citing Prior Patent Count**	**Independent Claim Count**
With selected research institutes	Non-Significant	Non-Significant	Non-Significant	Non-Significant

Patent test of well-known enterprises in domestic and abroad

The test of patent performance has chosen 10 of top 50 global enterprises of the well-known enterprises in domestic and abroad selected by the list of IFI CLAIMS® 2012 Top US Patent Assignees. Taiwan's selected enterprises has been put into this test of patent performance as this study targets for the later analysis. This study focus on the top 10% good patent quality performance between 2001 to 2004 and its performance will be test samples in this study. The test of patent performance is as below:

Table X: The patent performance of well-known enterprises in domestic and abroad

G Category Patents					
	Claim Count	**Filing Country Count**	**Citing Prior Patent Count**	**Patent Count**	**Independent Claim Count**
Average of selected foreign enterprise	26.43	3.07	8.84	5284	4.77
Average of selected foreign enterprise	21.82	1.45	2.91	104	2.97

H Category Patents					
	Claim Count	**Apply Country Count**	**Citing Prior Patent Count**	**Patent Count**	**Independent Claim Count**
Average of selected foreign enterprise	20.45	3.29	7.99	3607	3.78
Average of selected foreign enterprise	13.21	1.92	2.05	576	2.13

T-test result with selected well-known enterprises

RESEARCH FINDINGS AND CONCLUSIONS

After the above analysis and test, we could use three indicators and one aid for inspecting patent drafting quality, and also set the criterion value as follows:

Table X：Recommended patent drafting indicators and criterion value

G Category Patents				
	Claim Count	**Filing Country Count**	**Citing Prior Patent Count**	**Independent Claim Count**
Average	24.16	3.74	13.66	3.81
Recommended Criterion Value	24	4	14	4
H Category Patents				
	Claim Count	**Filing Country Count**	**Citing Prior Patent Count**	**Independent Claim Count**
Average	21.27	3.50	15.75	4.04
Recommended Criterion Value	21	4	16	4

Since current academic and practical assessment of patent quality often use patent citation analysis, this assessment information would take a long period after the patent been citied so that it is a bit lag behind practical need. Hence, one of main contribution of this project is to establish a set of assessment of patent quality that can be employed to judge patent quality directly from patent claims and its disclosure content. In this way, it will avoid the waste of R&D resource and will be useful for future patent portfolio strategy and patent management.

This project lies in the construction and validation of the drafting quality indicators of pilot patents. Using the samples of certified U.S. patent information during 2001-2004 as samples, this study adopted statistical methods to select the experimental indicators out of certified patents and is expected to deduce the content of the quality indicators of patents for drafting. This series of indicators are expected to become ways for the applicants to certify the quality of patents in early days of the application.

However, the quality and value of patents need to be approved for market certification, does not means that patents will get high quality if achieve the recommended criteria which this research proposed. This research propose this set of high quality patent drafting indicators and criteria is a reference for patent drafting and making portfolio, still depends on the practical application. Besides, research scope is limited by only using the G and H category US patents from 2001 to 2004, the following several suggestions for subsequent research:

1.   Using different annual patent samples, in order to track indicators arising due to the time change.
2.   Using different IPC category of patent samples, in order to compare different technology characteristics of indicators.

PHARMACEUTICAL'S WAREHOUSE MANAGEMENT WITH WORK STUDY, FORECASTING AND INVENTORY MANAGEMENT TECHNIQUES

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ABSTRACT

This research is a case study of the Atlanta Medicare Company Limited, a company with business operations in the form of a distribution center for pharmaceuticals that have significant limitations in areas of shelf life, storage areas, and employee work rate. Moreover, the business is in a sector that enjoys rapid growth caused by increasing consumer demand. Consequently, efforts are aimed at improvement of working methods to eliminate the various problematic limitations and to capably and efficiently support increased work volumes in areas of time and capital. The data studied in this research is initially obtained from observation of work methods in their original existing form through application of general problem-solving skills to identify bottlenecks in work operations and relevant work areas then connecting with industrial work study techniques, forecasting techniques, and inventory management techniques to analyze solutions for problems encountered in work methods at the bottleneck point. This relies on timing and observing the various work methods to gather and record the data into work process charts and workflow diagrams. The analysis results obtained by means of industrial study techniques will assist in comparative visualization prior to, and following, improvement of work methods. Additional forecasting techniques are applied to assess consumer needs in advance by selection of certain items, from the list of 47 pharmaceutical products, for Numerical Scoring combined with ABC Analysis principles. Monthly sales volume data has been gathered from the past 18 months to analyze via the Minitab 15 program. Moreover, data obtained from forecasting is applied to conduct appropriate analysis of sales order volume with further inventory management techniques. The aforesaid methods reveal problem points in the pharmaceutical distribution center, particularly in the product categorization operations sorted according to items ordered. Moreover, the expected results to be realized from the solutions and improvements rendered to the working methods by means of industrial work study techniques

include increased working efficiencies albeit with reduced working time and labor costs. The expected results from forecasting and product inventory management techniques will also help minimize losses incurred from inventory.

Keywords: Product Distribution Center, Industrial Work Study, Forecasting Techniques, Inventory Management Techniques.

INTRODUCTION

From the past until present, the 4 factors fundamental to human existence are food, housing, clothing, and medicine. Therefore, business operators within these various sectors, whom are capable to meet consumer demand, currently enjoy a high business growth rate – especially in businesses relevant to medicine. Data from the Office of Policy and Strategy at the Ministry of Public Health indicates that the number of patients is likely to increase substantially every year. This further confirms and reflects the results (Bureau of Policy and Strategy, 2012).

To optimize the response to consumer demand and enhance potential competitiveness according to the ever-increasing business growth rate among pharmaceuticals at present, pharmaceutical distribution enterprises must essentially have organizational management systems combined with prevention against losses that may incur as a result from both internal and external factors i.e. lack of volume, or exceeding consumer demand, order process management, storage and distribution processes, including medicine shelf-life etc. These various factors rely on industrial work operation research principles and inventory system design, which involves volume forecasting with uncertain demand, for the organization to capably and efficiently respond to consumer demand and ensure the highest benefit to the organization.

This research work originates from the aforesaid overview and is a case study of Atlanta Medicare Company Limited, a company with its work operations in the form of pharmaceutical distribution centers in a rapidly expanding growth sector owing to the increasing consumer demand and significant limitations in aspects of storage life. Thus, to capably and efficiently respond to consumer demand while creating maximum benefits to the organization, efforts are aimed at improving work methods to capably and efficiently support the increasing work volume while increasing speed of work operations at minimum operational cost and minimizing losses incurred from external factors i.e. uncertain consumer demand for pharmaceuticals and internal factors i.e. sales order procedures, inappropriate sales order behavior by manufacturers, and limitations in pharmaceutical storage life.

To create efficient consumer demand response capabilities and maximize benefits to the organization, various techniques have been applied that include Industrial Work Study Techniques, Forecasting Techniques, and Inventory Management Techniques. The Industrial

Work Study Techniques assist in generating results of maximum response capabilities for the increasing consumer demand by implementation of new work systems that further reduce operational costs (Barnes, 1980). The Forecasting Techniques assist in predicting consumer demand and enable us to set the ideal order volume to meet consumer demand. Finally, Inventory Management Techniques in this research are focused on order forms consistent with pharmaceutical products whereby the results used include order amounts or quantities obtained from Forecasting Techniques as a value for appropriate order calculation to enhance the delivery certainty of pharmaceuticals to clients and reduce the total annual inventory costs (Tersine, 1994). Ultimately, this increases opportunities to utilize funds for profit generation elsewhere and further raises the customer service levels.

METHODOLOGY

This research applies 3 methods i.e. Industrial Work Study, Forecasting, and Inventory Management.

Industrial Work Study

Specify the problem and analyze accordingly for applicable management approach in the case study of Atlanta Medicare Company Limited using general problem-solving procedures (Rachawan, 2009) comprised of the following.

1. Define the problem.

2. Specify criteria for decision.

3. Analyze the problem.

   3.1 Specify which work division has a bottleneck in the overall work processes.
The overall work processes are categorized in 3 portions as follows:
   - Portion 1: Receive orders from customers.
   - Portion 2: Organize customer orders.
   - Portion 3: Deliver customer orders.

This research takes into account bottlenecks that arise, during work operations, from minimum work volume obtained within one hour whereby the time and work volume in each portion is analyzed at random and consists of 5 random samples obtained per portion as illustrated below.
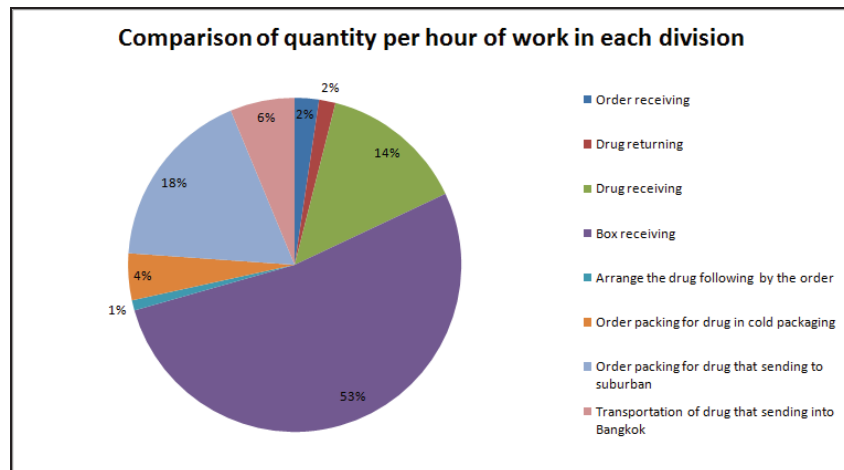
Figure 1: comparison of quantity per hour of work in each division
Source: self study based on research

3.2 From chapter 3.1, bottlenecks in work operation points are identified during Portion 2: Organize customer orders, when products are arranged to fulfill orders, and further considered to seek a solution. The aforesaid work operation point has problematic limitations i.e. pharmaceutical storage life, employee work rate, and product storage area capacity.

3.3 Tools applied to analyze current work methods at the operational point during Portion 2: Organize customer orders include the following.
- Operation Process Charts
- Flow Process Charts

Before timing can take place, the number of rounds timed must be calculated. This research requires the number of rounds timed set at 95% level of trust and no more than 15% level of error (Wanchai, 2012) calculated at the following formula.

$$N \quad = \quad (13.33\sqrt{n\sum X^2 - (\sum X)^2} / \sum X)^2$$

3.4 Determine areas for improvement.

- Improve the methodology. Apply ERP system to facilitate and increase speed in printing crate labels and packaging size analysis. (Yusuf et al, 2006) has studied the implementation of Enterprise Resource Planning (ERP) in the Peoples' Republic of China which entails Triple Play installation of ERP or an integrated process among personnel, technology, and process.

- Improve tools and facilitation equipment.Apply box tying machines to assist in sealing to replace transparent tape.

- Improve employees' work environment.Arrange pharmaceuticals on shelves for convenience in retrieval.

- Improve the work operation chart and pharmaceutical shelves consistent with the processes for fluid work operations.

Consider and seek solutions by means of brainstorming techniques.

Assess various comparisons to seek the optimal answer.
- Compare time results during work operations from the Flow Process Chart before and after improvement.
- Compare the increased or reduced costs incurred and further analyze the breakeven point in case of additional purchased equipment to replace original materials or equipment.
- Compare the original walking route to retrieve pharmaceuticals with the new shelf type.
- Compare the amount of pharmaceuticals returned prior to notification of return policy issued to clients with after the notification of return policy or conditions issued to clients.

Provide suggestions and follow-up results.

FORECASTING

- Gather consumer demand data of pharmaceuticals and consider past data over a period of 18 months.

- Rank the importance of pharmaceuticals by 3 decision factors as follows.

   - Profit per unit.
   - Storage area utilized per unit.
   - Sales volume over the period of 18 months.

The Numerical Scoring Model is applied with the following details.

1. Determine the weight values in each factor whereby Profit Per Unit carries a weight percentage value equal to 0.2; Storage Area Per Unit equal to 0.02; and Sales Volume equal to 0.78 (Takazawa, 2008).

2. Each pharmaceutical item is scored in each factor by a range divided into 5 equal periods whereby the scores in Period 1 to Period 5 contain values equal to 20 40 60 80 and 100 respectively as illustrated under Figure 31 and all details appear in the appendixes.

3. Each pharmaceutical item in each factor is considered to determine the factor's score period after which each pharmaceutical item in each factor is scored accordingly.

4. The weight score value of each factor is calculated from the formula = [Score of each pharmaceutical item in each factor (S) x Weight percentage (W)]

5. Seek the total weight score of 3 factors from the formula = $S_1W_1+S_2W_2+S_3W_3$

- Rank the total weight score value of each product from highest to lowest then group according to importance by application of ABC Analysis and consider specific forecasting of products in Group A with the following grouping conditions (Hanke, 1940).

    - Group A consists of 10 percent of all product items.
    - Group B consists of 30 percent of all product items.
    - Group C consists of 60 percent of all product items.

- Select forecasting methods consistent with data characteristics measured from MAPE values lower than the forecasted values by contrasting techniques. This research compares MAPE results from 2 forecasting techniques i.e. Simple Exponential Smoothing and Double Exponential Smoothing (Jain, 2001). Use of these 2 techniques arises from the data characteristics of demand from plotted graph.
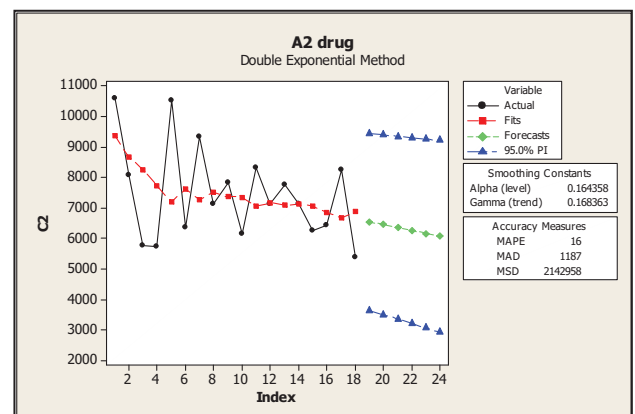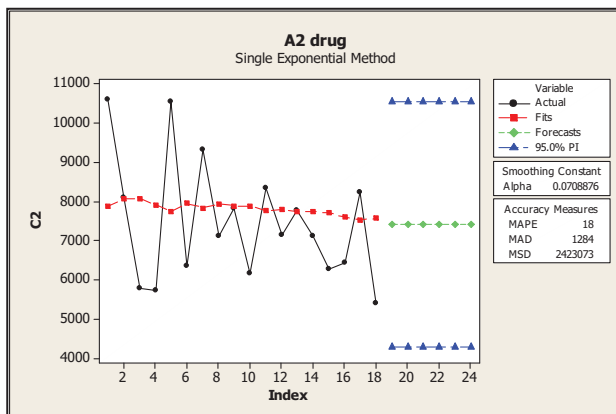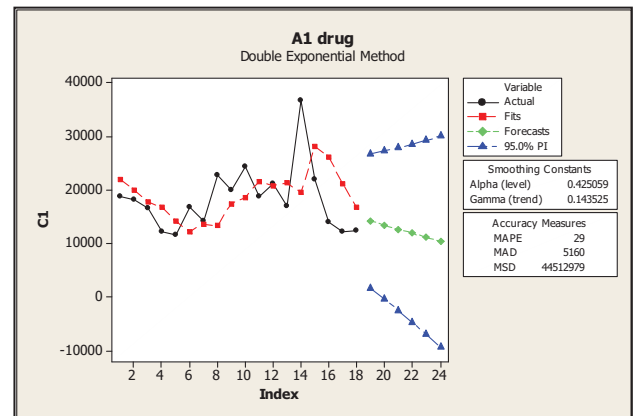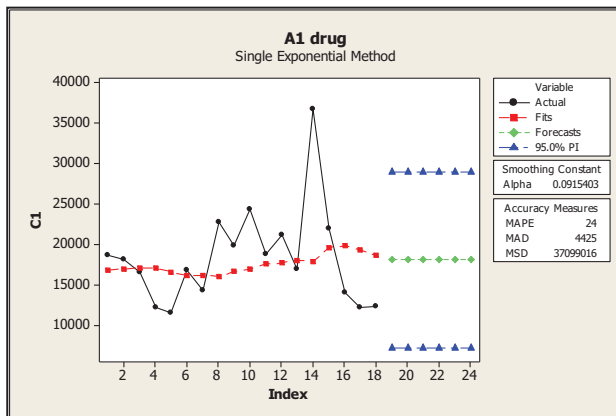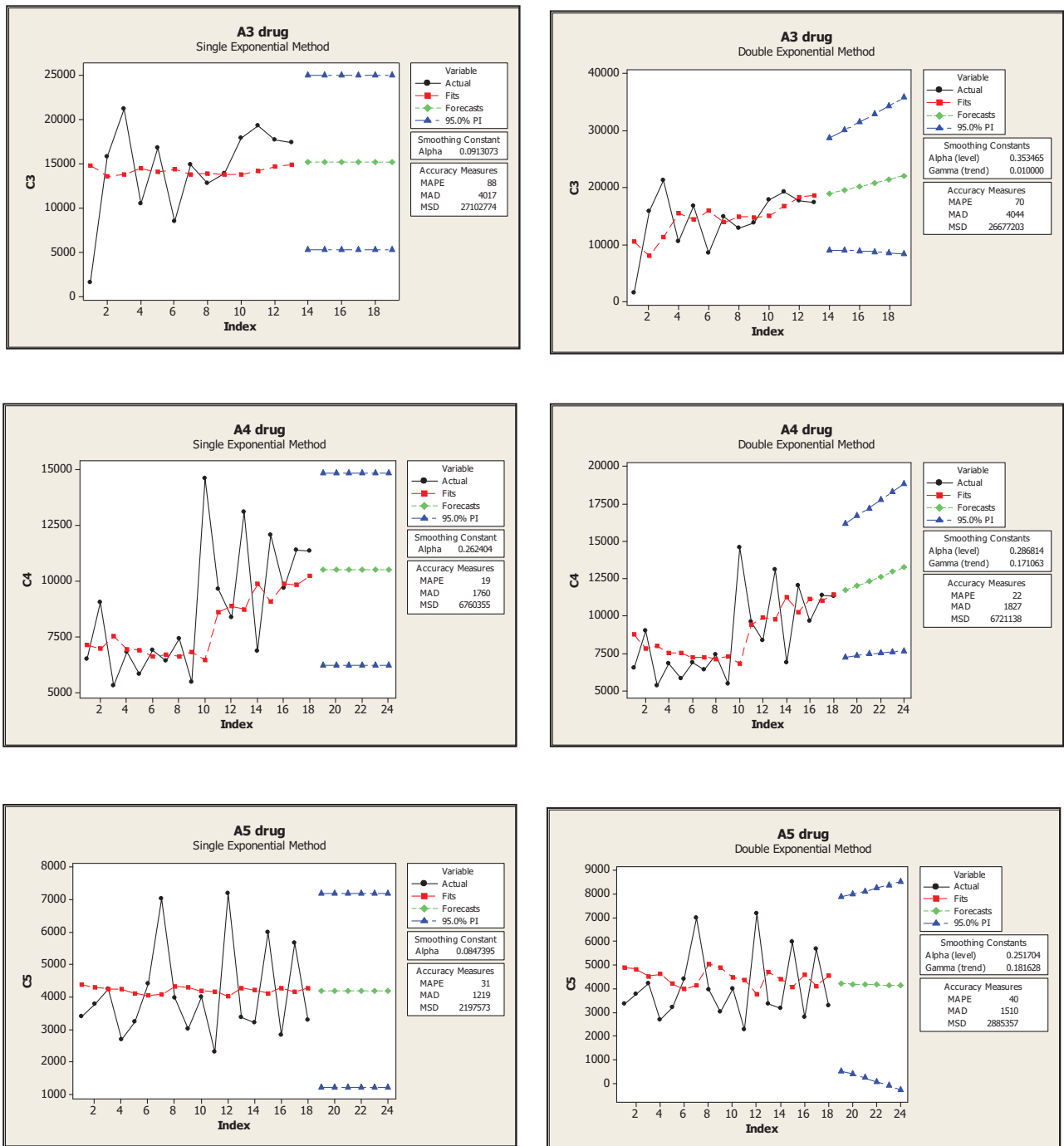
Figure 2: data characteristics of demand from plotted graph by Minitab 15
Source: self study based on research

INVENTORY MANAGEMENT

- Consider specific data of product items in Group A.

- Examine manufacturing sources of pharmaceuticals in Group A to determine if originated from single manufacturer or not.

- Select methods of considering sales order appropriate to the data.

- Since the pharmaceutical data under consideration is comprised of data with independent and consistent demand within a fixed time period, hence consideration of orders from the inventory management simulation must have independent demand with reorder point. There are 2 forms to consider and compare i.e. Fixed Order Quantity System and Fixed Order Period System (Water, 2007) as follows.

Fixed Order Quantity (FOQ: EOQ)

- Calculation of size of model ordered *(Q)* must be equal each time during each order period:

Formula: $Q^* = \sqrt{2SD/H}$

- Calculation of order distance *(T*)*:

Formula: $T^* = Q^*/D = \sqrt{2S/HD}$

- Calculation of order cost ($TC(Q^*)$):

Formula:
$$TC(Q^*) = \sqrt{2SHD} + CD$$
$$= CD + HQ^*$$

- Calculation of reorder point (ROP):

Formula: $ROP = D \times LT$

- Calculation of safe stock level (SS):

Formula: $ss = Z_\alpha \times \sigma_d \sqrt{LT}$

α is the value of chance of lack of goods obtained from:

Customer service level = 1- chance of lack of goods
(When the Company sets a customer service level policy at 95%)

σ_d is standard deviation in lead time

Fixed Order Period System (FOP: EOI)

α is the value of chance of lack of goods obtained from:

Customer service level = 1- chance of lack of goods
(When the Company sets a customer service level policy at 95%)

σ_d is standard deviation in lead time

Cases with multiple pharmaceutical items ordered
- Calculation of distance between multiple orders (T^*):

Formula:
$$T^* = \sqrt{\frac{2S}{H_1 D_1 + H_2 D_2 + H_3 D_3}}$$

- Calculation of multiple order costs ($TC(T^*)$):

Formula:
$$TC(T^*) = CD + HDT^*$$

- Compare the total annual cost by consideration of the 2 order forms and actual selection of the form that incurs the lowest total annual costs (of which at present the Company applies EOQ to consider orders) (Zipkin, 2000)

SUMMARY OF RESULTS

Through combined application of Industrial Work Study Techniques and Inventory Management Techniques to solve problems encountered in the original work model and to increase competitiveness to the organization, the following results have been obtained:

>> Total reduced expenses:
1. Changed box and sealing methods.
2. Less overtime payments when work hours are reduce following improvements.
3. Changed order methods from Fixed Order Quantity (EOQ) to Fixed Order Period (EOI) system.
Total savings of 489,032.02 Baht / year (0.58%)
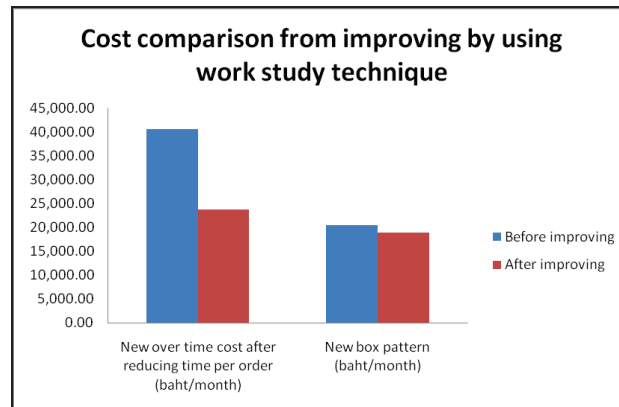
Figure 3: cost comparison from improving by using work study technique
Source: self study based on research
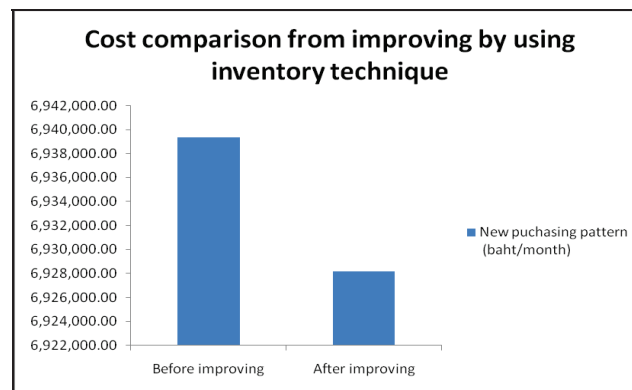
Figure 4: cost comparison from improving by using inventory technique
Source: self study based on research

>> Working hours saved (19.42%) compared with before and after improvements as illustrated in the graph below.

>> Increased order volume efficiency = 422 Order / Month = 24.10%

In areas forecasted by MAPE comparison, we choose to apply forecasting techniques that offer the lowest MAPE value. Simple Exponential Smoothing applies advance demand volume forecast for A1, A4, and A5 pharmaceuticals whereas Double Exponential Smoothing applies advance demand volume forecast for A2 and A3 pharmaceuticals.

REFERENCE

1. Rachawan Kanchanapanyakom. 2009. Industrial Work Study. Top Publishing Co., Ltd, Bangkok, 21-40

2. Wanchai Rijiravanich. 2012. Work Study : principle and case study. 8th ed. Chulalongkorn University Publishing, Bangkok.

3. Bureau of Policy and Strategy. 2555 http://social.nesdb.go.th/SocialStat/StatReport_Final.aspx?reportid=226&template=2R1 C&yeartype=M&subcatid=17

4. Barnes, R.M. 1980. Motion and Time Study, John Wiley and Sons Inc, New York.

5. Hanke, John E., 1940. Business forecasting, Needham Height, United States of America.

6. Jain, C.L. 2001. Academic journal article from The Journal of Business Forecasting Methods & Systems, Vol.20 No.2

7. Takazawa, K. 2008. A weighted even factor algorithm. Math. Program. 115, 223–237

8. Tersine, R.J. 1994. Principles of Inventory and Materials Management, Prentice Hall, Englewood Cliffs, New Jersey.

9. Water, D. 2007. Inventory Control, John Wiley and Sons Inc, England.

10. Zipkin, P.H. 2000. Foundations of Inventory Management, McGraw-Hill ,Irwin.

11. Yusuf, Y. and A. Gunasekaran, and C. Wu. 2006. Implemention of enterprise resource planning in China (Electronic version). **Technovation** 26 (12): 1324-1336.

A CASE STUDY OF THE SYSTEM DYNAMICS MODEL TO EVALUATE THE PERFORMANCES OF MRP AND DEMAND DRIVEN MRP

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ABSTRACT

Purpose: The core function of ERP system in manufacturing is Material Requirement Planning(MRP). But the results of MRP implementation in today's most of the enterprise are too much shortage or excess inventory. Therefore it have been required a lots of informal efforts for inventory planning & execution. That's because today's enterprise environment have been increased in complexity and uncertainty not only demand but also supply side. MRP can only make the good results under the no uncertainty and predetermined fixed condition like the paradise. Demand Driven MRP(DDMRP) was published by Carol Ptak and Chad Smith to overcome the MRP's weakness as a multi-echelon materials and inventory planning and execution solution. But there is no research paper yet to compare the MRP and DDMRP in performances. This study will compare how much difference in performances of MRP and DDMRP at the same situations on demand and supply side uncertainty.

Design/Methodology: Design the model by System dynamics CLD(Causal Loop Diagram) and STD(Stock Flow Diagram). VENSIM DSS version 6.00 is used as the data simulation tool to compare the difference in performance in MRP and DDMRP

Findings: Generally most of enterprises regard that the less inventory level, the more in profit. But the proper level of inventory buffering is more important to reactive on demand and supply uncertainties. This study shows that DDMRP with strategic inventory buffer management increase the performance and how is different from MRP with safety stock by the simulation data.

Originality/Value: The comparing the performance of MRP and DDMRP by system dynamics simulation model can show the exact the differences with the time series. Also this simulation model will be upgraded to compare data with actual enterprise data to reduce the trial error loss for process innovation.

A CASE STUDY OF eWOM : USING VOICE OF CUSTOMERS FOR BUILDING REPUTABLE SYSTEM

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ABSTRACT

Our study aims at finding the correlation between eWOM and the box office income to examine the operation mode of viral marketing. All variables of eWOM are collected based on the reputation hierarchy developed by the semantic interpretation. There layers of this reputation hierarchy can measure the importance respectively. The top layer of our hierarchy is reputation followed by layer that consists of expertise and trustworthiness. The sub-layer of expertise is constituted by knowledge and competence. Variables belong to knowledge are mostly the text characteristics and timeliness. To express competence here, we adopt the transformed RFM model here is used to measure the influence of the reviewer. The sub-layer of trustworthiness is constituted by quality of content and writing style. The variable for quality of content should be reliable. Regarding writing style, we adopt the variables derived from LIWC factors and 4 indicators of emotions. By using simple concept of statistics, the outcome of the hierarchical regression is also intuitive. Coinciding with the tendency of online users, timely reviews of sufficient information in the neat expression can promote the box office income. Impatient online users obviously prefer different opinions while the rating score is relatively high than the sentimental reviews. The principle of viral marketing is to create the uninterrupted buzz online. Our result shows the tendency and signals the marketers for better manipulation.

Keywords: reputation system, eWOM, text analysis, reputation hierarchy

INTRODUCTION

With the rapid development of Web technology, eWOMs have evolved from simply a link in your friends' Hotmail into countless online reviews posted by total strangers. The possibility to efficiently retrieve the optimal information for users themselves plummets. Unlike the endorsement from anyone on your contact list (Jurvetson and Draper 1997), online reviews from nameless strangers require a proper operation to prove their credibility, which is called information asymmetry by Wilson (1983). As a result, reputation systems pop up for consumers' key reference. Reputation systems are extensively applied to various types of online sites such as auction sites, expert sites, and product review sites. EBay is a good example to explain the functions of reputation systems applied to auction sites. After the delivery of the purchased goods or services, sellers and buyers can mutually assess the quality by rating based on their personal perception. Mostly the essence of reputation systems is rating each other with or without brief explanations through every deal. Resnick, Zeckhauser et al. (2000) stated reputation systems that collect, distribute, and aggregate feedback about users' past behavior help people decide whom to trust and what to purchase.

With reputation system to display the continuous records of the past history of users in public helps enhance mutual understanding and the probability to make a deal among strangers. Obviously, reputation can be considered the public opinion as defined by Jiao, Liu et al. (2013). If the reputation system is well operated, the optimal information can be retrieved efficiently, users could be motivated to share their experience on the internet, and the market can fairly developed, which means the higher quality the sellers offer, the more the premium can be enjoyed by the sellers. As far as users are concerned, expecting future reciprocity would have online users tend to interact in a positive and aggressive manner. Looking forward to tangible or intangible benefits in the near future, users shielded by pseudonym system would think over before they leap. (Resnick, Zeckhauser et al. 2000)

Cape NO. 7 is a distinct case that the strength of eWOM is maximized in only 4 months, from August to December in 2008 when the economy recession just began. On a tight budget of 50 million N.T. dollars, the box office income earned by Cape NO. 7 is 530 million N.T. dollars. Inspired by Cape NO. 7, the contribution to the success of Cape NO. 7 is mainly attributed to eWOM disseminated by numerous bloggers. We couldn't help wondering what factors make eWOM so powerful. Researchers have been immersed themselves in extracting the pertaining constructs of the reputation system and the characteristics of the posted texts to examine their relationships to sales revenue variation (Ghose and Ipeirotis 2008) or to retrieve reviews of good information quality (Chen and Tseng 2011). Social networks and trust networks are also used as the tools to rank websites and reviewers by evaluating their existing reputations. (Toms and Taves 2004, Ku, Wei et al. 2012). However, the possibility to represent the reputation as a hierarchy is skirted. Integrating the characteristics of the review and the reviewer on imdb.com to fit in with the 3 level Reputation Hierarchy, a hierarchical

regression model is formed to separately estimate the explanatory power of different levels and further figure out what are important dimensions to pay close attention for eWOMs. Through the deconstruction of semantic interpretation of reputation, the correspondingly developed hierarchy would offer some more comprehensible information for general marketers.

LITERATURE REVIEW

In this chapter, firstly, the concepts related to reputation are introduced to develop a hierarchy based on various interpretations from different researchers. Then, an overview across the existing literature is to collect and integrate available indicators.

Conceptualization of Reputation Hierarchy

Intangible reputation, existed only by the third party's perception of a person, an object, or an organization, can be positive, neutral, or negative. Reputation is also the mirror to reflect the past behavior patterns. (Toms and Taves 2004) Acquisition of reputation could be categorized into 3 conditions. One condition is that people form their personal perception directly in the process of interactions, which shows consistency would inspire the peculiar belief or expectation. Then opinions are disseminated to generate eWOMs in the real and virtual life. The crowd would produce their personal perception by absorbing a considerable number of opinions, which is the second condition to form reputation indirectly. The last one is borrowing reputation from other reputable resources such as being recommended from celebrities, experts, or organization, or owning physical equipment, e.g., extravagant furniture or expensive estate (Weigelt and Camerer 1988), or being awarded, prized, and certified (Whitmeyer 2000), or "renting another agent's reputation" as mentioned by Chu and Chu (1994). An example in the work of Chu and Chu (1994) is selling products through a reputable retail trader to obtain reputation. Whether the reputation is produced directly by personal experience or indirectly by eWOMs or other reputable sources, it would probably be the accessible information to shape one's belief or expectation about what is discussed. People might be easily affected in the decision-making process by one's belief or expectation because of information asymmetry. (Wilson 1983) and that is why reputation is so important in a group of strangers, for example, an online community.

Reputation is multi-dimensional as no single factor can perfectly determine one's reputation. (Toms and Taves 2004) Many researchers soaked themselves in finding crucial factors leading people to shape perception. Source authority and credibility are highlighted as 2 important dimensions to impact reputation especially where there is no authoritative organization to be referred in the relatively uncontrolled Web environment (Rieh and Belkin 1998). First of all, source authority can affect the perceived quality of information (Wilson 1983) and credibility that is called believability and defined as the perceived quality have been examined correlated with expertise and trustworthiness (Fogg and Tseng 1999, Fogg,

Marshall et al. 2001). The meaning of credibility here is further extended to be reputation based on the same interpretation in the Oxford English Dictionary. Reputation is defined as "the relative estimation or esteem in which a person or thing is held" (Simpson and Weiner 1989) Considering that source authority is always dependent on the existing reputation of the information provider, we rule out this factor while probing reputation on the Web. Therefore, expertise and trustworthiness are 2 major factors contributing to reputation, which constitute our 1st lay of our hierarchy.

Progressively, researchers found more terms to conceptualize reputation. Some web sites whose activities are mainly to evaluate the information quality on the Web highlighted the importance of the following concepts on reputation, such as relevance, reliability, authority (Science Academy, 2001), or quality of content, usability, and authority (Argus Associate, 2001). Chen and Tseng (2011) collected 51 factors and categorized them in 9 dimensions, namely believability, objectivity, reputation, relevancy, timeliness, completeness, appropriate amount for information, ease of understanding, and concise representation in order. All factors are on the parallel line probably because they solely intended to classify reviews to information quality. As the synonym of reputation, we also noticed indicators of credibility as Rubin and Liddy (2006) published include four main categories: blogger's expertise and offline identity disclosure; blogger's trustworthiness and value system; information quality; and appeals and triggers of a personal nature. The importance of previously mentioned factors in existing literature is believed to be hierarchical. Accordingly, we allocate some of the above mentioned concepts for 2 factors: expertise and trustworthiness based on the general comprehension.

Unlike trustworthiness, two or three words are proposed to explain the given expertise, such as expertness or authority. But all of them are deemed the synonym of expertise (Hovland, Janis et al. 1953, Toms and Taves 2004). Two inherence characteristics of authority are "knowledge and competence" respectively (Fogg and Tseng 1999, Fogg, Marshall et al. 2001). Therefore, both factors can constitute expertise. Knowledge is regarded as the amount of information in reviews (Chen and Tseng 2011). As for competence, we extract an adaption of RFM model on reviewer (Li, Lin et al. 2010).

Our reputation hierarchy is developed from the semantic perspective, referring to the given meaning of Trust in the Oxford English Dictionary is "confidence in or reliance on some quality or attribute of a person or thing, or the truth of a statement" (Simpson & Weiner, 1989, vol. XVIII, p. 623). So factors qualified to be under Trust should be consistent and reliable. To match these attributes, variables related to quality of content and writing style are chosen. Quality of content are composed of 3 variables that are respectively spell errors, Flesch Reading Ease, evidentiality. Of all, evidentiality is derived from the linguistic cues that is also treated as "fingerprinting" of people's writing. Writers couldn't quit their own linguistic cues even when they are performing different writing styles. (King and Pennebaker 1999) As for writing style, we calculate the writing score by using the sum of 4 LIWC factors, which are

proved to be correlated with 5 Big Personality Traits in the study of King and Pennebaker (1999). Also, emotions and affects embedded in reviews are also considered influential variables of writing style here as both variables help reader understand what the reviewers convey and also arouse echoes among readers.

Believability belongs to the dimension of writing style as it can represent the reviewer's subjectivity to some extent.

METHODOLOGY AND ANALYSIS

Internet movie database, also known as IMDb.com is a perfect example for marketing of digital content. Starting its operation in 1990, IMDb.com turns one of AMAZON subsidiaries in 1996.

Data preprocess
Reviews of 108 movies on the TOP 250 movies list are retrieved from IMDb.com. After removing all the null values, the rest reviews are 61,000 in total, but only reviews posted in the first 6 weeks when the movie is in theaters are reserved as people are no longer interested in one movie with the lapse of time. As a result, eWOM activity gradually disappear in 6 weeks (Liu 2006). Every review is daily aggregated to take all the influential factors into consideration. To the end, there are 42 observations sorted by week. Total number of observations is 2,100 for 50 movies. Statistics numbers are standardized by min-max method after extracted.

Hierarchical Regression
The proposed model uses dimensionality reduction for preprocessing the Likes data, which are then entered into logistic or linear regression to predict individual psycho-demographic profiles from Likes. Pearson correlation coefficient, AUC area, and test-retest reliability are applied. (Kosinski, Stillwell et al. 2013). Hierarchical or multilevel model, a simplified path analysis, is widely applied to interpret human behavior in social science. Upon the confirmation of the correlation between x and y, variables in given dimensions are entered orderly into the regression equation to testify whether one or more dependent variables are correlated with the selected independent variable. By observing the performance of R2 values in different dimensions, the impact power can be clearly estimated (Gelman 2007).
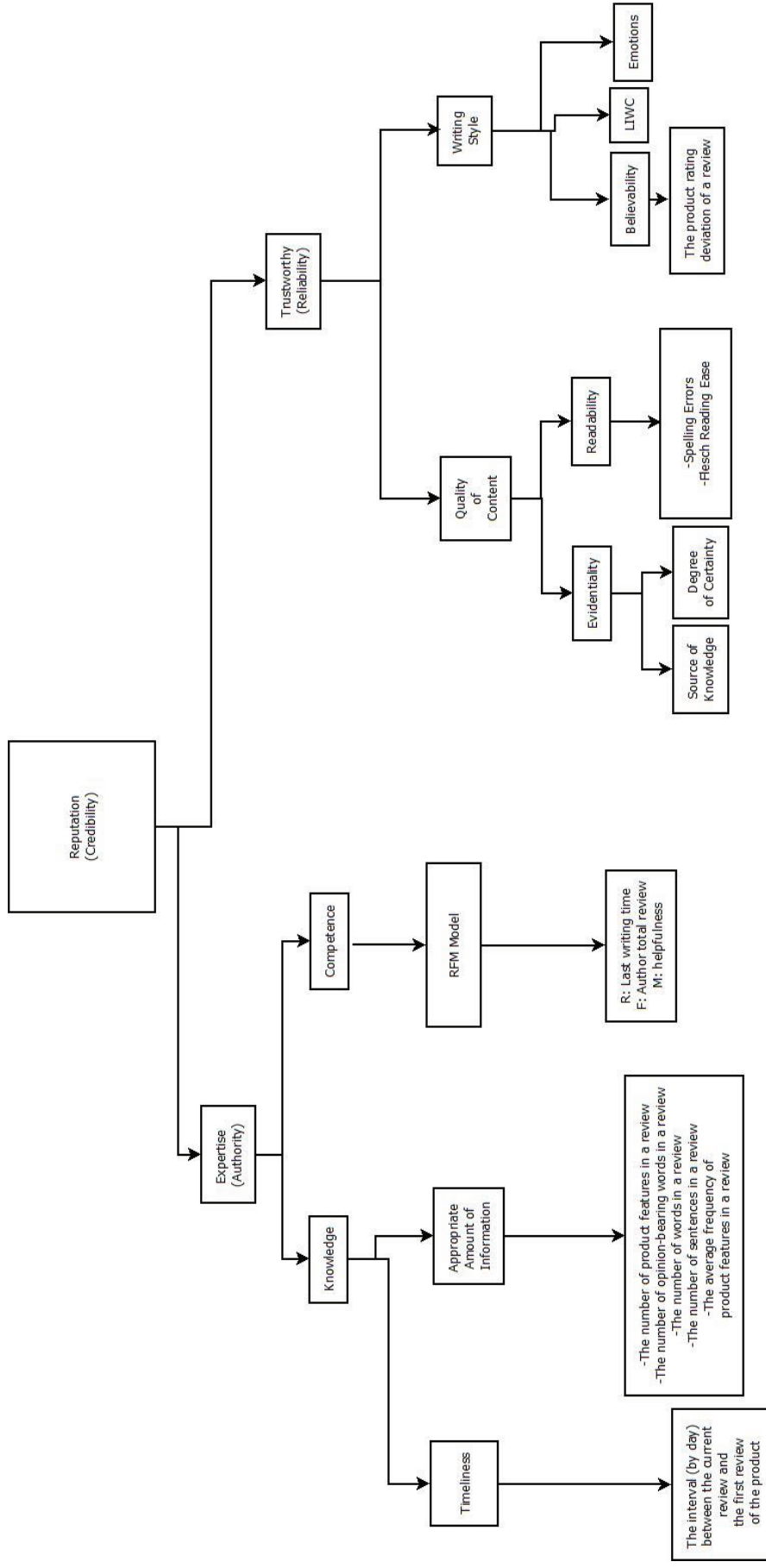
Figure 1: Reputation hierarchy

Seeing that trust, reviewer characteristic, reviewer history, review readability, and review subjectivity are deemed accurate predicators of sales variation (Jarvenpaa, Tractinsky et al. 1999, Ghose and Ipeirotis 2008), our reputation hierarchy is applied to examine the correlation between the gross sales and all relevant factors in dimensions of the hierarchy. First step is to measure the relationship between all above mentioned variables and the gross sales. The explanatory power is 74.4% and all variables are distinct. We'll perform the hierarchy model to observe the accumulated varitations by week. Later on, only significant variables stay for further analysis. The estimate values of emotions, anger & disgust, fear, sadness, and joy, are calculated by the relative distance in a 3 dimensional model.

Table 1. Coefficient and *p*-value of hierarchical regression

Duration		WEEK 1		WEEK 1-2		WEEK 1-3		WEEK 1-4		WEEK 1-5		WEEK 1-6	
	（常數）	0.764	0.000	0.634	0.000	0.474	0.000	0.370	0.000	0.282	0.000	0.232	0.000
K01	avgtimeliness	-4.013	0.000	-0.644	0.000	-0.210	0.003	-0.059	0.149	0.004	0.876	0.027	0.142
K02	avgreviews	0.323	0.000	0.430	0.000	0.520	0.000	0.577	0.000	0.607	0.000	0.625	0.000
K03	avgwc	-0.101	0.227	-0.152	0.017	-0.094	0.038	-0.066	0.045	-0.052	0.045	-0.051	0.017
K04	avgwps	-0.023	0.530	-0.061	0.024	-0.057	0.004	-0.040	0.010	-0.037	0.003	-0.032	0.002
K05	avgfeaturenum	0.023	0.624	0.003	0.936	0.005	0.860	0.010	0.626	0.012	0.481	0.018	0.193
K06	avgsen_feature	0.188	0.036	0.045	0.510	-0.018	0.714	-0.023	0.556	-0.030	0.346	-0.029	0.257
K07	avgsen_op	-0.025	0.777	0.152	0.024	0.135	0.006	0.098	0.010	0.085	0.005	0.073	0.003
C01	avglast_writing	-0.040	0.290	-0.026	0.364	-0.008	0.709	-0.015	0.327	-0.016	0.171	-0.015	0.146
C02	avgtotreviews	-0.061	0.102	-0.035	0.179	-0.006	0.733	-0.007	0.635	-0.012	0.324	-0.014	0.161
C03	avghelpful	0.008	0.793	0.008	0.750	-0.003	0.875	-0.002	0.896	0.002	0.834	0.001	0.929
Q01	avgevidentially	0.015	0.726	-0.004	0.901	0.000	0.987	0.000	0.985	-0.004	0.807	0.000	0.978
Q02	avgreadability	-0.003	0.943	0.072	0.024	0.046	0.040	0.041	0.019	0.031	0.026	0.025	0.026
Q03	avgspell_error	-0.059	0.077	-0.011	0.670	0.020	0.264	0.023	0.090	0.015	0.174	0.009	0.339
W01	avgrating	0.205	0.000	0.118	0.003	0.071	0.008	0.057	0.004	0.062	0.000	0.066	0.000
W02	avgBelievability	-0.023	0.741	0.263	0.000	0.311	0.000	0.313	0.000	0.297	0.000	0.269	0.000
W03	avgwriting_score	0.011	0.753	-0.006	0.839	0.000	0.978	0.001	0.927	0.001	0.946	0.003	0.802
W04	avganger_disgust	-0.193	0.218	-0.322	0.010	-0.281	0.003	-0.251	0.001	-0.231	0.000	-0.213	0.000
W05	avgfear	0.353	0.172	0.431	0.028	0.351	0.016	0.317	0.005	0.277	0.003	0.246	0.002
W06	avgsadness	-0.519	0.030	-0.693	0.000	-0.588	0.000	-0.521	0.000	-0.424	0.000	-0.361	0.000
W07	avgjoy	-0.282	0.093	-0.500	0.000	-0.460	0.000	-0.415	0.000	-0.349	0.000	-0.310	0.000

In every week, the explanatory power of each significant variables varies. Significant variables in the first week lead an interesting interpretation. Timeliness, review volume per movie, and feature-mentioned sentence of knowledge as well as rating and sadness of writing style are correlated with the sales. Timeliness is negatively correlated with the sales revenue, which means the immediate a review is posted, the more the sales can be created. As for a movie, review volume, feature-contained sentence, and rating are all positively correlated with the sales. Sadness as a significant variable is quite tricky here. Referring to the coefficient of sadness, the surmise is moviegoers might pay close attention to the deficiencies before they decide to go to the movie theater. Sadness in reviews might hint the reviewer's regrets. To sum up, in the first week, a movie review that affects the box office earning

should be quickly posted, capable of offering sufficient descriptions of features and deficiencies accurately.

In week 2, timeliness, review volume, and feature-mentioned sentence remain influential. Timeliness, word count, word count per sentence are negatively correlated with the gross sales, which shows internet users that are eager to retrieve a considerable amount of information are impatient with the long and profound articles. opinion-mentioned sentence, rating, believability that are positively correlated with the sales reveal the reviewer's attitude toward the focal movie impacts the moviegoers, which is paradoxical that moviegoers still prefer discriminative ideas while the rating is on the high side. However, anger & disgust and joy are negatively correlated. The explanation might be that the rational and objective content is favored. By week 3, new significant variable, readability is positively correlated in week 1-3, which testifies user's tendency for easier articles. Interesting, spell error is ignored among users, which indirectly verified that "reading is a psycholinguistic guessing game." Readers combine their thought and language to form their perception of online reviews and the spell errors don't bother them (Goodman 1967)."
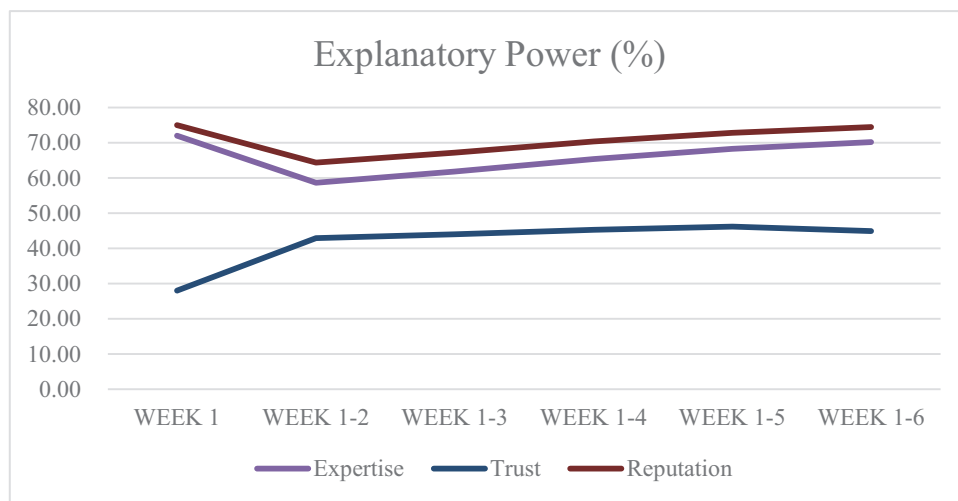
Figure 2: Line chart of explanatory power per dimension

Recall to our reputation hierarchy, in the bottom layer, competence of reviewer and quality of content contributes nothing to the gross sales. What actually boosts the gross sales in expertise is a large amount of knowledge that is neatly and accurately expressed. Besides, users still pay more attention to the diverse voices while the total rating score is on the high side. The more affective the text is, the less the gross sales are earned.

In the middle layer, the explanatory power of expertise is higher than that of trust. It's pity that the influence of the factors that are relevant to the reviewer or linguistic cues are comparatively weaker. LIWC factors are very strong predictor to personality but when it

comes to the gross sales, the explanatory power is comparatively weaker. Otherwise, more psycholinguistic views can be deeply discussed.

CONCLUSION

In our study, the deconstruction of reputation brings us the opportunity to discriminate the importance of 3 layers. As for the studies of online reviews, there are two typical researches. One is to apply many machine-learning methods to categorize reviews by information and relevance (Chen and Tseng 2011). The other one is to examine the relationship between the sales and the characteristic of review and reviewer. This type of study have some factors related to the reviewer's offline social status and point of view taken into consideration while estimating impact on the sales variation (Ghose and Ipeirotis 2008). To put theory into practice, the importance of the variables should be clarified. After the deciphering of reputation, we can clearly measure the explanatory power of 3 layers. Accordingly, we find out the importance of expertise is more than that of trustworthiness. According to the deduction, marketers can make more efforts to stir the heat of online discussion instead of assigning a few reputable bloggers or reviewers to post some expensive articles. However, if the goal is to clearly deliver the brand image to the online users rather than sales orientation, finding some reputable reviewers and bloggers is a great idea. The result of our study coinciding with the principle of viral marketing, the individual peculiarity is nothing important, writing style of any reviewer expressed in linguistic cues is not as influential as other variables derived by text characteristics.

Movie is the experience goods, so marketers might try to create echoes to promote sales. Therefore, emotional persuasion might be adopted. Here, according to our result, emotion persuasion is no longer a good idea to market movies. The heat of the discussion is the key point for viral marketing. Aiming at promoting the sales, marketers should pay close attention to keep the heat of online discussion instead of finding the reputable bloggers or reviews to post a few articles unless your goal is to establish the brand image.

Nowadays, impatient online users prefer that knowledge is simplified and easy to understand. If they need to take 5 minutes or more to read online articles, they might leave within a split second. Although the impact of readability is only valid after week 3, two simple and intuitive factors, word count and word count per sentence both reveal their impact one week earlier. Obviously, viewers dislike the sentimental reviews. Getting too emotional might incur negative impressions from the public. Another contradiction is that the viewers seek the unique viewpoint when the rating score is generally high. This might reveal the viewers' tendency to collect the information from different perspectives to make the best decision.

REFERENCE

1. Aichner, T. (2012). "The Zero Moment of Truth in Mass Customization." International Journal of Industrial Engineering and Management **3**(4): 173-178.
2. Bradley, M. M. and P. J. Lang (1999). Affective norms for English words (ANEW): Instruction manual and affective ratings, Technical Report C-1, The Center for Research in Psychophysiology, University of Florida.
3. Calvo, R. A. and S. Mac Kim (2012). "Emotions in text: dimensional and categorical models." Computational Intelligence.
4. Chen, C. C. and Y. D. Tseng (2011). "Quality evaluation of product reviews using an information quality framework." Decision Support Systems **50**(4): 755-768.
5. Chu, W. and W. Chu (1994). "Signaling quality by selling through a reputable retailer: An example of renting the reputation of another agent." Marketing Science **13**(2): 177-189.
6. Fogg, B., et al. (2001). What makes Web sites credible?: a report on a large quantitative study. Proceedings of the SIGCHI conference on Human factors in computing systems, ACM.
7. Fogg, B. and H. Tseng (1999). The elements of computer credibility. Proceedings of the SIGCHI conference on Human factors in computing systems: the CHI is the limit, ACM.
8. Gelman, A. (2007). Data analysis using regression and multilevel/hierarchical models, Cambridge University Press.
9. Ghose, A. and P. G. Ipeirotis (2008). "Estimating the Socio-Economic Impact of Product Reviews-mining text and reviewer characteristics." NYU Stern Research Working Paper.
10. Goodman, K. S. (1967). "Reading: A psycholinguistic guessing game." Literacy Research and Instruction **6**(4): 126-135.
11. Henderson, B. D. (1979). "The product portfolio: growth share matrix of the Boston Consulting Group." The strategy process: Concepts, contexts, cases: 678-680.
12. Hovland, C. I., et al. (1953). "Communication and persuasion; psychological studies of opinion change."
13. Jarvenpaa, S. L., et al. (1999). "Consumer Trust in an Internet Store: A Cross-Cultural Validation." Journal of Computer-Mediated Communication **5**(2): 0-0.
14. Jiao, H., et al. (2013). "A Paradox for Trust and Reputation In the E-commerce World."
15. Jindal, N. and B. Liu (2008). Opinion spam and analysis. Proceedings of the international conference on Web search and web data mining, ACM.
16. Jurvetson, S. and T. Draper (1997). "Viral marketing." Netscape M-Files **1**.
17. King, L. A. and J. W. Pennebaker (1999). "Linguistic styles: Language use as an individual difference." Journal of Personality and Social Psychology **77**(6): 1296-1312.
18. Kosinski, M., et al. (2013). "Private traits and attributes are predictable from digital records of human behavior." Proceedings of the National Academy of Sciences **110**(15): 5802-5805.
19. Ku, Y.-C., et al. (2012). "To whom should I listen? Finding reputable reviewers in

opinion-sharing communities." <u>Decision Support Systems</u> **53**(3): 534-542.

20. Li, Y. M., et al. (2010). "Identifying influential reviewers for word-of-mouth marketing." <u>Electronic Commerce Research and Applications</u> **9**(4): 294-304.

21. Liu, Y. (2006). "Word of mouth for movies: Its dynamics and impact on box office revenue." <u>Journal of marketing</u>: 74-89.

22. Mau, M. J. <u>The success equation : untangling skill and luck in business, sports, and investing / Michael J. Mau</u>, Mauboussin, Michael J., 1964-.

23. Pennebaker, J. W., et al. (2001). "Linguistic inquiry and word count: LIWC 2001." <u>Mahway: Lawrence Erlbaum Associates</u>: 71.

24. Resnick, P., et al. (2000). "Reputation systems." <u>Communications of the ACM</u> **43**(12): 45-48.

25. Rieh, S. Y. and N. J. Belkin (1998). <u>Understanding judgment of information quality and cognitive authority in the WWW</u>. Proceedings of the 61st annual meeting of the american society for information science, Citeseer.

26. Rubin, V. L. and E. D. Liddy (2006). "Assessing Credibility of Weblogs."

27. Simpson, J. A. and E. S. Weiner (1989). <u>The Oxford english dictionary</u>, Clarendon Press Oxford.

28. Su, Q., et al. (2010). "Evidentiality for Text Trustworthiness Detection." <u>Proceedings of the 2010 Workshop on NLP and Linguistics: Finding the Common Ground</u>: 10-17.

29. Toms, E. G. and A. R. Taves (2004). "Measuring user perceptions of Web site reputation." <u>Information Processing & Management</u> **40**(2): 291-317.

30. Weigelt, K. and C. Camerer (1988). "Reputation and corporate strategy: A review of recent theory and applications." <u>Strategic Management Journal</u> **9**(5): 443-454.

31. Whitmeyer, J. M. (2000). "Effects of positive reputation systems." <u>Social Science Research</u> **29**(2): 188-207.

32. Wilson, P. (1983). <u>Second-hand knowledge: An inquiry into cognitive authority</u>, Greenwood Press Westport, CT.

33. Science Academy. (2001). How to find information on the Web. Available:

http://www.scienceacademy.com/find.html (2001). The Argus clearinghouse.

VERTEX-FAULT-TOLERANT PATHS EMBEDDING ON FOLDED HYPERCUBE NETWORK TOPOLOGIES

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ABSTRACT

The folded hypercube (FQ_n for short) is a well-known variation of hypercube structure and can be constructed from a hypercube by adding a link to every pair of vertices with complementary addresses. Let f be a faulty vertex in FQ_n, for $n \geq 2$. Let u and v be any two fault-free vertices in $FQ_n - \{f\}$. It has been shown that (1) $FQ_n - \{f\}$ contains a fault-free path $P[u,v]$ of every length l with $d_{FQ_n}(u,v) + 2 \leq l \leq 2^n - 3$ and $2 \mid l - d_{FQ_n}(u,v)$, where $n \geq 2$; (2) $FQ_n - \{f\}$ contains a fault-free $P[u,v]$ path of every length l with $n - 1 \leq l \leq 2^n - 3$, where $n \geq 2$ is even. In this paper, we extend the above result to obtain two further properties as follows: (1) $FQ_n - \{f\}$ contains a fault-free path $P[u,v]$ of every length l with $d_{FQ_n}(u,v) \leq l \leq 2^n - 3$ and $2 \mid l - d_{FQ_n}(u,v)$ for $n \geq 2$; (2) $FQ_n - \{f\}$ contains a fault-free path $P[u,v]$ of every length l with $n - 1 \leq l \leq 2^n - 2$ for $n \geq 2$ is even.

Keywords: Folded hypercubes, interconnection networks, bipartite graphs, fault-tolerant embedding, path.

INTRODUCTION

Design of *interconnection networks* is an important integral part of parallel processing and distributed systems. The *hypercube* is a well-known interconnection network model. The hypercube has several excellent properties, such as recursive structure, regularity, symmetry, small diameter, short mean internode distance, low degree, and much smaller edge complexity, which are very important for designing massively parallel or distributed systems [5, 15-17, 20, 25, 26]. Numerous variants of the hypercube have been proposed in the literature [2, 3, 19, 21, 23]. One variant that has been the focus of a great deal of research is the *folded hypercube*,

which can be constructed from a hypercube by adding a link to every pair of vertices that are the farthest apart, i.e., two vertices with complementary addresses. The folded hypercube has been shown to be able to improve the system's performance over a regular hypercube in many measurements, such as diameter, fault diameter, connectivity, and so on [2, 4, 18, 27, 28, 31].

An important feature of an interconnection network is its ability to efficiently simulate algorithms designed for other architectures. Such a simulation can be formulated as *network embedding*. An *embedding* of a *guest network* G into a *host network* H is defined as a one-to-one mapping f from vertices in G into vertices in H so that a link of G corresponds to a path of H under f [16]. The embedding strategy allows us to emulate the effect of a guest graph on a host graph. Then, algorithms developed for a guest graph can also be executed well on the host graph.

Linear arrays (*paths*), the fundamental networks for parallel and distributed computing, are suitable for designing simple algorithms with low communication costs. Numerous efficient algorithms based on paths for solving various algebraic problems and graph problems can be found in [16]. These algorithms can be used as control/data flow structures for distributed computing in arbitrary networks.

Since faults may occur when a network is put into use, it is practically meaningful and important to consider faulty networks. Previously, the problem of fault-tolerant embedding on an n-dimensional folded hypercube FQ_n has been studied in [6-14, 27, 29, 30]. In this paper, we consider the faulty folded hypercube with one faulty vertex f. We obtain the following two properties:

1. $FQ_n - \{f\}$ contains a fault-free path between any two fault-free vertices u and v of every length l with $d_{FQ_n}(u,v) \le l \le 2^n - 3$ and $2 \mid l - d_{FQ_n}(u,v)$, where $n \ge 2$.

2. $FQ_n - \{f\}$ contains a fault-free path between any two fault-free vertices u and v of every length l with $n - 1 \le l \le 2^n - 2$, where $n \ge 2$ is even.

The remainder of this paper is organized as follows: in Section 2, we provide some necessary definitions, notations, and basic topology properties. We present our main result in Section 3. Some concluding remarks are given in Section 4.

PRELIMINARIES

In this paper, a network topology is represented by a simple undirected graph, which is loopless and without multiple edges. We denote the vertex set and edge set of a graph G by $V(G)$ and $E(G)$, respectively. Throughout this paper, the terms *network* and *graph*, *node* and *vertex*, *link* and *edge* are used interchangeably. Two vertices u and v are *adjacent*, if $(u,v) \in E(G)$, and u and v are the *end-vertices* of (u,v). Two adjacent vertices are called *neighbors* each other. A *path*, denoted by $\langle v_0, v_1, v_2, \ldots, v_k \rangle$, is a sequence of distinct vertices $v_0, v_1, \ldots, v_k$ in which any two consecutive vertices are adjacent. We call v_0 and v_k the *end-vertices* of the path. A path with end-vertices u and v, denoted by $P[u,v]$. In addition, a path may contain a *subpath*, denoted as $\langle v_0, v_1, \ldots, v_i, P[v_i, v_j], v_j, v_{j+1}, \ldots, v_k \rangle$, where $P[v_i, v_j] = \langle v_i, v_{i+1}, \ldots, v_{j-1}, v_j \rangle$. The *length* of the path $P[u,v]$, denoted by $\|P[u,v]\|$, is the number of edges on the path. The *distance* between u and v is the smallest length of any path $P[u,v]$ in G, which can be denoted by $d_G(u,v)$ or simply $d(u,v)$ if there is no ambiguity. A path $\langle v_0, v_1, \ldots, v_k \rangle$ forms a *cycle* if $v_0 = v_k$. A path (resp. cycle) in G is called a *Hamiltonian path* (resp. *Hamiltonian cycle*) if it contains every vertex of G exactly once. G is said to be *Hamiltonian* if it contains a Hamiltonian cycle, and *Hamiltonian-connected* if there exists a Hamiltonian path between any two distinct vertices of G. Furthermore, a graph G is said to be *panconnected* if there exists a path of every length between any two distinct vertices from its distance to $\|V(G)\| - 1$.

A graph G is *bipartite* if $V(G)$ can be partitioned into two *partite sets* V_0 and V_1 such that $V_0 \cap V_1 = \varnothing$ and $E(G) \subseteq \{(u,v) \mid u \in V_0 \text{ and } v \in V_1\}$. A Hamiltonian bipartite graph G is *Hamiltonian-laceable* if there exists a Hamiltonian path between any two vertices in different partite sets. A Hamiltonian-laceable graph $G = (V_0 \cup V_1, E)$ is *strong* if there is a simple path of length $\|V_0\| + \|V_1\| - 2$ between any two vertices of the same partite set. A Hamiltonian-laceable graph $G = (V_0 \cup V_1, E)$ is *hyper Hamiltonian laceable* if for any vertex $v \in V_i, i = 0,1$, there is a Hamiltonian path in $G - \{v\}$ between any two vertices of V_{1-i}, where $G - \{v\}$ is the graph obtained by deleting v from G. A graph G is said to be *bipanconnected* if for any pair of different vertices u and v with distance $d(u,v)$ in G, there exists a path $P[u,v]$ of length $d(u,v) \le l \le \|V(G)\| - 1$ and $2 \mid l - d(u,v)$. An *isomorphism* from a simple graph G to a simple graph H is a one-to-one and onto function $\pi: V(G) \to V(H)$ such that $(u,v) \in E(G)$ iff $(\pi(u), \pi(v)) \in E(H)$. We say G is isomorphic

to H, written as $G \cong H$, if there is an isomorphism from G to H. An *automorphism* of G is an isomorphism from G to G.

An n-*dimensional hypercube* Q_n can be represented as an undirected graph such that $V(Q_n)$ consists of 2^n vertices which are labeled as binary strings of length n from $\underbrace{00...0}_{n}$ to $\underbrace{11...1}_{n}$. Each edge $e = (u,v) \in E(Q_n)$ connects two vertices u and v if and only if u and v differ in exactly one bit of their labels, i.e., $u = b_n b_{n-1}...b_k...b_1$ and $v = b_n b_{n-1}...\overline{b_k}...b_1$, where $\overline{b_k}$ is the *one's complement* of b_k, i.e., $\overline{b_k} = 1-i$ iff $b_k = i$ for $i = 0,1$. For convenience, the vertex v can be denoted as $v = u^{(k)}$ and we call that e an edge of *dimension* k. Clearly, each vertex connects to exactly n other vertices. In addition, there are 2^{n-1} edges in each dimension and $|E(Q_n)| = n \cdot 2^{n-1}$. Figure 1 shows a 2-dimensional hypercube Q_2 and a 3-dimensional hypercube Q_3.
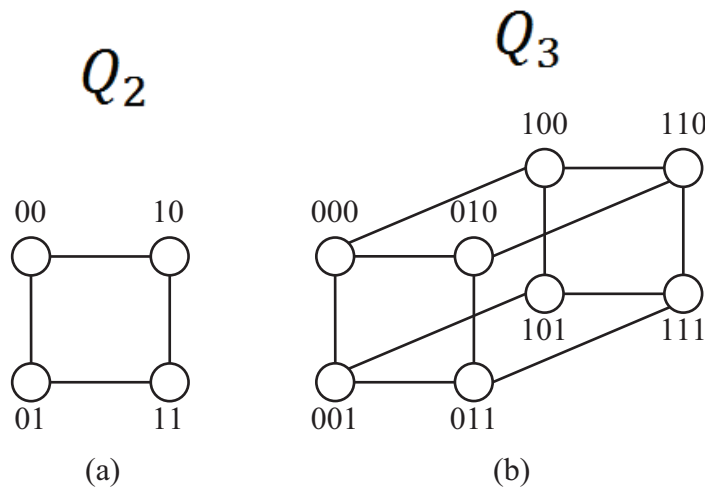
Figure 1: Q_2 and Q_3

Let $x = x_n x_{n-1}...x_1$ and $y = y_n y_{n-1}...y_1$ be two n-bit binary strings. The *Hamming distance* $h(x,y)$ between two vertices x and y is the number of different bits in the corresponding strings of both vertices. The *Hamming weight* $hw(x)$ of x is the number of i's such that $x_i = 1$. Note that Q_n is a bipartite graph with two partite sets $\{x \mid hw(x) \text{ is odd}\}$ and $\{x \mid hw(x) \text{ is even}\}$. Let $d_{Q_n}(x,y)$ be the *distance* between two vertices x and y in graph Q_n. Clearly, $d_{Q_n}(x,y) = h(x,y)$.

An n-*dimensional folded hypercube* FQ_n is a regular n-dimensional hypercube augmented by adding more edges among its vertices. More specifically, FQ_n is obtained by

adding an edge (also called *complementary edge*) to every pair of vertices whose address are complementary to each other; i.e., vertex $x = b_n b_{n-1} \cdots b_1$ and vertex $\bar{x} = \overline{b_n}\ \overline{b_{n-1}} \cdots \overline{b_1}$. Figure 2 shows a 2-dimensional folded hypercube FQ_2 and a 3-dimensional folded hypercube FQ_3. Note that an n-dimensional folded hypercube can be partitioned into two node-disjoint $(n-1)$-dimensional hypercubes by removing the hypercube edges in some dimension and all the complimentary edges. It has been shown that FQ_n is $(n+1)$-regular, $(n+1)$-connected, node-transitive, edge-transitive [29]. For convenience, let $\widetilde{V}(FQ_n)$ and $\widetilde{E}(FQ_n)$ be the sets of faulty vertices and faulty edges in FQ_n respectively.
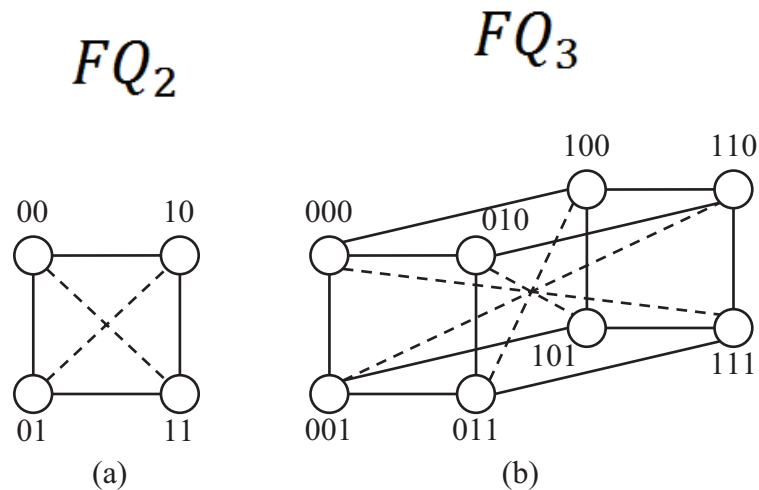
Figure 2: FQ_2 and FQ_3

In the remainder of this section, we consider some previously reported results of path (cycle) embedding in hypercubes and folded hypercubes, as they are useful to our method.

Lemma 1   [16] *Let u and v be any two vertices in Q_n, for $n \geq 2$. Then, there exists a path $P[u,v]$ of every length l in Q_n with $h(u,v) \leq l \leq 2^n - 1$ and $2 | l - h(u,v)$.*

Lemma 2   [24] *Let V_0 and V_1 be the partite sets of a fault-free Q_n, where $n \geq 2$. In addition, u and v are two distinct vertices of V_0; and u' and v' are two distinct vertices of V_1. Then, there exist two node-disjoint paths $P_1[u,u']$ and $P_2[v,v']$ such that $V(P_1[u,u']) \cup V(P_2[v,v']) = V(Q_n)$.*

Lemma 3 [1] *Let* u *and* v *be any two fault-free vertices in* $FQ_n - \widetilde{V}(FQ_n) - \widetilde{E}(FQ_n)$ *with* $\left|\widetilde{V}(FQ_n)\right| + \left|\widetilde{E}(FQ_n)\right| \le n - 2$. *Then, we have the following two properties:*

1. $FQ_n - \widetilde{V}(FQ_n) - \widetilde{E}(FQ_n)$ contains a fault-free path $P[u,v]$ of every length l with $d_{FQ_n}(u,v) + 2 \le l \le 2^n - 2\left|\widetilde{V}(FQ_n)\right| - 1$ and $2 \mid l - d_{FQ_n}(u,v)$, where $n \ge 2$.

2. $FQ_n - \widetilde{V}(FQ_n) - \widetilde{E}(FQ_n)$ contains a fault-free path $P[u,v]$ of every length l with $n - 1 \le l \le 2^n - 2\left|\widetilde{V}(FQ_n)\right| - 1$, where $n \ge 2$ is even.

Lemma 4 [1] *Let* u *and* v *be any two vertices in* FQ_n. *Then, there exists* $n + 1$ *internally node-disjoint paths* $P[u,v]$ *such that* $h(u,v)$ *of them are of length* $h(u,v)$ *and the others are of length* $n + 1 - h(u,v)$.

Lemma 5 [22] *Let* Q_n *be an* n *-dimensional hypercube with* $\left|\widetilde{E}(Q_n)\right| \le n - 2$. *Then,* $Q_n - \widetilde{E}(Q_n)$ *is hyper-Hamiltonian-laceable, where* $n \ge 3$.

Lemma 6 *Let* u *and* $u^{(i)}$ *be two adjacent faulty vertices in* Q_n *and connected by an* i *-dimensional edge, where* $1 \le i \le n$. *Then,* $Q_n - \{u, u^{(i)}\}$ *contains a fault-free path* $P[v, v^{(j)}]$ *of length* $2^n - 3$ *between any two adjacent vertices* v *and* $v^{(j)}$, *where* $1 \le j \le n$, $j \ne i$ *and* $n \ge 3$.

Proof: We prove this lemma by induction on n. For the base case $n = 3$, since Q_3 is edge-symmetric, without loss of generality we may assume that the two faulty adjacent vertices are $u = 000$ and $u^{(1)} = 001$. Table 1 shows that $Q_n - \{u, u^{(1)}\}$ contains a fault-free path $P[v, v^{(j)}]$ of length 5 between any two adjacent vertices v and $v^{(j)}$, where $j \in \{2,3\}$. Thus, the base case holds.

Table 1: $P[v, v^{(j)}]$ in Q_3 with two faulty adjacent vertices 000 and 001.

j	v	vʲ	$P[v, v^{(j)}]$
2	100	110	$\langle 100, 101, 111, 011, 010, 110 \rangle$
2	101	111	$\langle 101, 100, 110, 010, 011, 111 \rangle$
3	010	110	$\langle 010, 011, 111, 101, 100, 110 \rangle$
3	011	111	$\langle 011, 010, 110, 100, 101, 111 \rangle$

Assume that the lemma is true for $n = k-1$, $k \geq 4$. Now we consider the situation for $n = k$. We can partition Q_k along dimension m, where $m \neq i, j$ and $1 \leq m \leq k$, into two $(k-1)$-dimensional hypercubes Q_{k-1}^0 and Q_{k-1}^1 so that u and $u^{(i)}$ are in the same subcube, and v and $v^{(j)}$ are in the same subcube. Without loss of generality, we assume that $u, u^{(i)} \in V(Q_{k-1}^0)$. Then, we consider the following two cases.

Case 1: $v, v^{(j)} \in V(Q_{k-1}^0)$.

By the induction hypothesis, $Q_{k-1}^0 - \{u, u^{(i)}\}$ contains a fault-free path $P_0[v, v^{(j)}]$ of length $2^{k-1} - 3$. Let (x, y) be an edge in $P_0[v, v^{(j)}]$. Note that $P_0[v, v^{(j)}]$ can be represented by $\langle v, P_0'[v, x], x, y, P_0'[y, v^{(j)}], v^{(j)} \rangle$. By the definition of hypercube, $x^{(m)}$ and $y^{(m)}$ are the neighbors of x and y in Q_{k-1}^1, respectively. By Lemma 1, Q_{k-1}^1 contains a fault-free path $P_1[x^{(m)}, y^{(m)}]$ of length $2^{k-1} - 1$. Therefore, a fault-free path $P[v, v^{(j)}]$ can be constructed as $\langle v, \ P_0'[v, x], \ x, \ x^{(m)}, \ P_1[x^{(m)}, y^{(m)}], \ y^{(m)}, \ y, \ P_0'[y, v^{(j)}], v^{(j)} \rangle$ with length $(2^{k-1} - 3) - 1 + 2 + (2^{k-1} - 1) = 2^k - 3$, as shown in Figure 3(a).
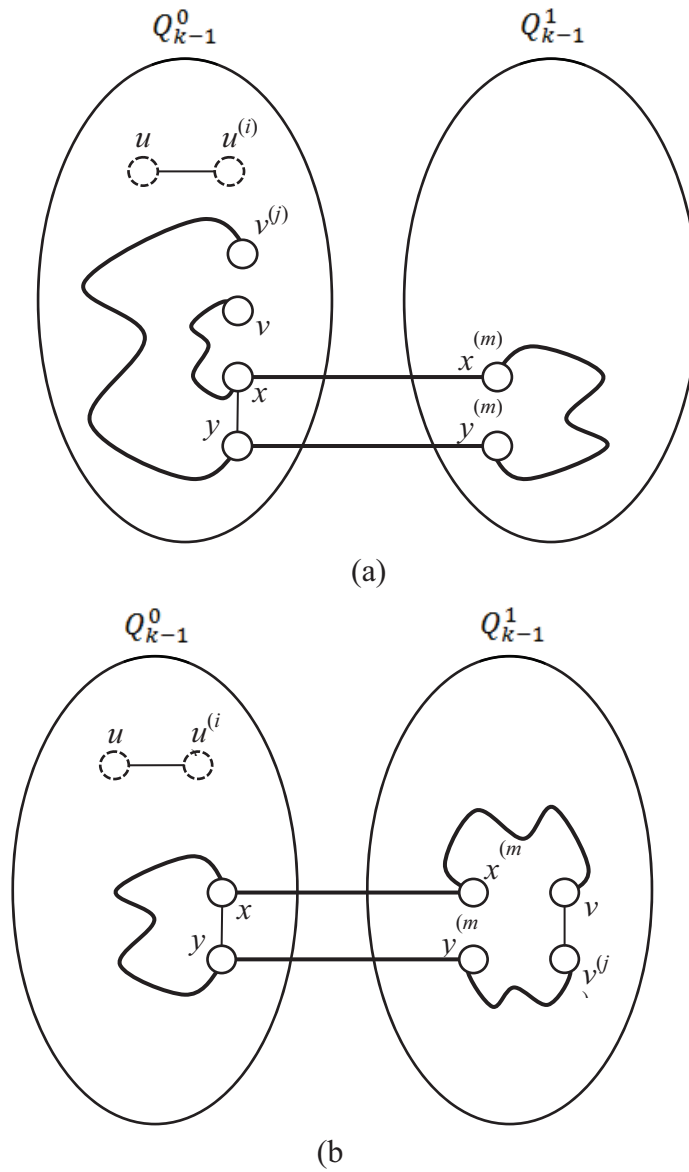
Figure 3: An illustration of the proof of Lemma 6

Case 2: $v, v^{(j)} \in V(Q_{k-1}^1)$.

Let (x, y) be a j-dimensional edge in $Q_{k-1}^0 - \{u, u^{(i)}\}$ such that $\{x^{(m)}, y^{(m)}\} \cap \{v, v^{(j)}\} = \varnothing$. Without loss of generality, we assume that v and $y^{(m)}$ are in the same partite set. By Lemma 2, Q_{k-1}^1 contains two node-disjoint paths $P_1[v, x^{(m)}]$ and $P_1'[y^{(m)}, v^{(j)}]$ such that $V(P_1[v, x^{(m)}]) \cup V(P_1'[y^{(m)}, v^{(j)}]) = V(Q_{k-1}^1)$. Note that

$\left|P_1[v,x^{(m)}]\right| + \left|P_1[y^{(m)},v^{(j)}]\right| = 2^{k-1} - 2$. Furthermore, by the induction hypothesis, $Q^0_{k-1} - \{u,u^{(i)}\}$ contains a fault-free path $P_0[x,y]$ with length $2^{k-1} - 3$. Therefore, a fault-free path $P[v,v^{(j)}]$ can be constructed as $\langle v, \; P_1[v,x^{(m)}], \; x^{(m)}, \; x, \; P_0[x,y], \; y,y^{(m)}, \; P_1[y^{(m)}, \; v^{(j)}], \; v^{(j)} \rangle$ with length $(2^{k-1} - 3) + 2 + (2^{k-1} - 2) = 2^k - 3$, as shown in Figure 3(b).

By combining above cases, we complete the proof.   **Q.E.D.**

EXTENDED BIPANCONNECTIVITY AND PANCONNECTIVITY OF FOLDED HYPERCUBES

In this section, we present our main result as follows.

Theorem 1 *Let* f *be a faulty vertex in* FQ_n, *where* $n \geq 2$. *In addition, let* u *and* v *be any two fault-free vertices in* $FQ_n - \{f\}$. *Then,* $FQ_n - \{f\}$ *contains a fault-free path* $P[u,v]$ *of every length* l *with* $d_{FQ_n}(u,v) \leq l \leq 2^n - 3$ *and* $2 | l - d_{FQ_n}(u,v)$.

Proof: For $n = 2$, FQ_2 is a complete graph with four vertices, i.e., K_4. It is easy to check that the theorem holds for $n = 2$.

We now consider the situation when $n \geq 3$. By Lemma 3(1), $FQ_n - \{f\}$ contains a fault-free path $P[u,v]$ of every length l with $d_{FQ_n}(u,v) + 2 \leq l \leq 2^n - 3$ and $2 | l - d_{FQ_n}(u,v)$. Therefore, we only need to consider the remaining case that $l = d_{FQ_n}(u,v)$. By Lemma 4, there exist $n + 1$ internally node-disjoint paths between u and v in FQ_n such that $h(u,v)$ of them are with length $h(u,v)$ and the others are with length $n + 1 - h(u,v)$. Moreover, since the diameter of FQ_n is $\lceil \frac{n}{2} \rceil$, the distance $d_{FQ_n}(u,v)$ is either $h(u,v)$ or $n + 1 - h(u,v)$. Then, we consider the following two scenarios.

Case 1: $d_{FQ_n}(u,v) = h(u,v)$.

We first consider the case that $d_{FQ_n}(u,v) = h(u,v) = 1$. Since u and v are fault-free vertices, the edge (u,v) is fault-free. Then, (u,v) is the desired path $P[u,v]$ of length $l = d_{FQ_n}(u,v) = 1$. Next, we consider the remaining the case that $d_{FQ_n}(u,v) = h(u,v) \geq 2$. By Lemma 4, there exist $h(u,v)(\geq 2)$ paths $P[u,v]$ of length $h(u,v)$ in FQ_n. Therefore, $FQ_n - \{f\}$ contains desired $h(u,v) - 1 \geq 1$ fault-free paths $P[u,v]$ of length $h(u,v)$.

Case 2: $d_{FQ_n}(u,v) = n + 1 - h(u,v)$.

First, we consider the case that $d_{FQ_n}(u,v) = n + 1 - h(u,v) = 1$, which results in $h(u,v) = n$, i.e., edge (u,v) is a complementary edge. Moreover, since u and v are fault-free vertices, (u,v) is fault-free. Then, (u,v) is the desired path $P[u,v]$ of length $l = d_{FQ_n}(u,v) = n + 1 - h(u,v) = 1$. Next, we consider the remaining case that $d_{FQ_n}(u,v) = n + 1 - h(u,v) \geq 2$. By Lemma 4, there exist $n + 1 - h(u,v)(\geq 2)$ paths $P[u,v]$ of length $n + 1 - h(u,v)$ in FQ_n. Therefore, $FQ_n - \{f\}$ contains $n + 1 - h(u,v) - 1 \geq 1$ desired fault-free paths $P[u,v]$ of length $n + 1 - h(u,v)$.

The result holds from the above two cases.   **Q.E.D.**

Next, we present our second main result reguarding panconnectivity of folded hypercubes.

Theorem 2   *Let* f *be a faulty vertex in* FQ_n, *where* $n \geq 2$ *is even.* $FQ_n - \{f\}$ *contains a fault-free path* $P[u,v]$ *of every length* l *with* $n - 1 \leq l \leq 2^n - 2$, *where* u *and* v *are any two fault-free vertices in* FQ_n.

Proof: For $n = 2$, FQ_2 is a complete graph with four vertices, namely K_4. It is easy to check that $FQ_2 - \{f\}$ contains a fault-free path $P[u,v]$ of every length l with $1 = 2 - 1 \leq l \leq 2^2 - 2 = 2$. We now consider the situation that $n \geq 4$ is even. By Lemma 3(b), $FQ_n - \{f\}$ contains a fault-free path $P[u,v]$ of every length l with $n - 1 \leq l \leq 2^n - 3$. Hence, we only need to consider the case where $l = 2^n - 2$. First, we can partition FQ_n along dimension k, where $1 \leq k \leq n$, into two $(n-1)$-dimensional hypercubes Q_{n-1}^0 and Q_{n-1}^1 such that u and v are in different subcubes. Without loss of generality, assume that $k = n$, $u \in V(Q_{n-1}^0)$, $v \in V(Q_{n-1}^1)$, and $f \in V(Q_{n-1}^0)$. For the Hamming distance between u and v, i.e., $h(u,v)$, we consider the following two scenarios.

Proceedings of 2014 International Conference on
Technology Innovation and Industrial Management
28th-30th May 2014, Seoul, South Korea

Case 1: $h(u,v)$ is odd. That is, u and v are in different partite sets. For the parity of f, we further consider two subcases.

Case 1.1: f and u are in the same partite set, i.e., $h(f,u)$ is even.

Let $p = f^{(i)}$ be a neighbor of f in Q^0_{n-1}, where $1 \le i \le n-1$, such that $\overline{p} \ne v$ [1]. In addition, let $q = u^{(j)}$ be a neighbor of u in Q^0_{n-1}, where $1 \le j \ne i \le n-1$, such that $q \ne p$ [2]. By Lemma 6, $Q^0_{n-1} - \{f,p\}$ contains a fault-free path $P[u,q]$ of length $2^{n-1} - 3$. Moreover, by Lemma 2, Q^1_{n-1} contains two node-disjoint paths $P[q^{(n)}, \overline{p}]$ and $P[p^{(n)}, v]$ such that $V(P[q^{(n)}, \overline{p}]) \cup V(P[p^{(n)}, v]) = V(Q^1_{n-1})$ and thus $\left| P[q^{(n)}, \overline{p}] \right| + \left| P[p^{(n)}, v] \right| = 2^{n-1} - 2$. Therefore, the desired fault-free path $P[u,v]$ can be constructed as $\langle u, P[u,q], q, q^{(n)}, P[q^{(n)}, \overline{p}], \overline{p}, p, p^{(n)}, P[p^{(n)}, v], v \rangle$ of length $l = (2^{n-1} - 3) + 1 + (2^{n-1} - 2) + 2 = 2^n - 2$ (see Figure 4).
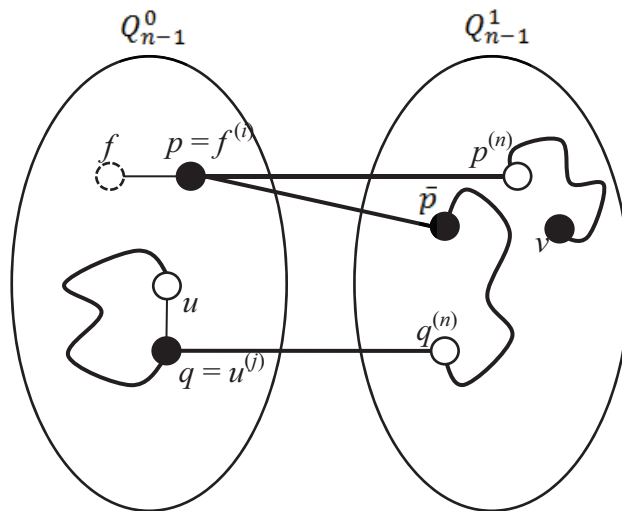
Figure 4: An illustration of Case 1.1 in the proof of Theorem 2

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[1] Since (1) $h(u,v)$ is odd, (2) $h(f,u)$ is even, and (3) $h(p, \overline{p})$ is even ($\because n \ge 4$ is even), we have that $h(\overline{p}, v)$ is even, i.e., $\overline{p}$ and v are in the same partite set. Moreover, since $\left| \{f^{(i)} \mid 1 \le i \le n-1\} \right| \ge 3 > 1 = \left| \{v\} \right|$, there must exist i such that $\overline{p} \ne v$.

[2] Since $\left| \{u^{(j)} \mid 1 \le j \ne i \le n-1\} \right| \ge 2 > 1 = \left| \{p\} \right|$, there must exist such vertex q in Q^0_{n-1}.

Case 1.2: f and u are in different partite sets, i.e., $h(f,u)$ is odd.

Let $p = f^{(i)}$ be a neighbor of f in Q_{n-1}^0, where $1 \leq i \leq n-1$, such that $p \neq u$ and $p^{(n)} \neq v$ [3]. In addition, let $q = u^{(j)}$ be a neighbor of u in Q_{n-1}^0, where $1 \leq j \neq i \leq n-1$, such that $q \neq f$. Since $q^{(n)}$ and $\bar{p}$ are in the same partite set, we further consider the following two subcases.

(a)

(b)
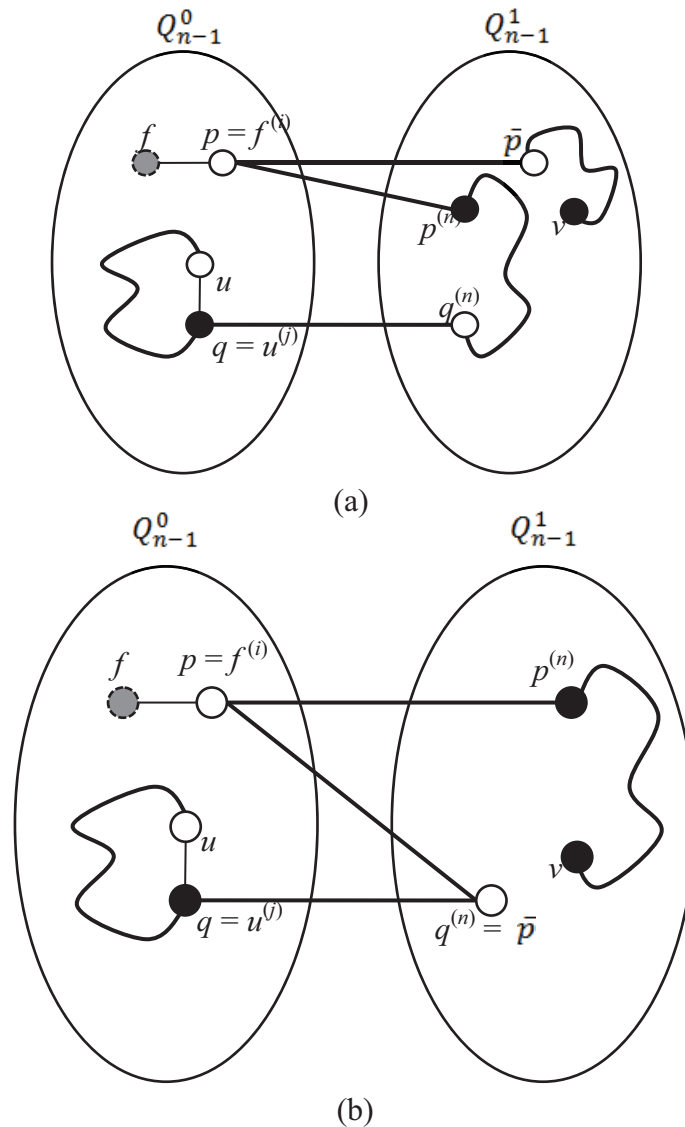
Figure 5: An illustration of Case 1.2 in the proof of Theorem 2

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[3] Since (1) $h(u,v)$ is odd, (2) $h(f,u)$ is odd, and (3) $h(p,p^{(n)})$ is odd, we have that $h(p^{(n)},v)$ is even, i.e., $p^{(n)}$ and v are in the same partite set. Moreover, since $\left|\{f^{(i)} \mid 1 \leq i \leq n-1\}\right| \geq 3 > 2 = \left|\{u,v\}\right|$, there must exist i such that $p \neq u$ and $p^{(n)} \neq v$.

Case 1.2.1: $q^{(n)} \neq \bar{p}$.

According to Lemma 6, $Q_{n-1}^0 - \{f, p\}$ contains a fault-free path $P[u,q]$ of length $2^{n-1} - 3$. Moreover, according to Lemma 2, Q_{n-1}^1 contains two node-disjoint paths $P[q^{(n)}, p^{(n)}]$ and $P[\bar{p}, v]$ such that $V(P[q^{(n)}, p^{(n)}]) \cup V(P[\bar{p}, v]) = V(Q_{n-1}^1)$ and thus $|P[q^{(n)}, p^{(n)}]| + |P[\bar{p}, v]| = 2^{n-1} - 2$. Therefore, the desired fault-free path $P[u,v]$ can be constructed as $\langle u, P[u,q], q, q^{(n)}, P[q^{(n)}, p^{(n)}], p^{(n)}, p, \bar{p}, P[\bar{p}, v], v \rangle$ of length $l = (2^{n-1} - 3) + 1 + (2^{n-1} - 2) + 2 = 2^n - 2$ (see Figure 5(a)).

Case 1.2.2: $q^{(n)} = \bar{p}$.

According to Lemma 6, $Q_{n-1}^0 - \{f, p\}$ contains a fault-free path $P[u,q]$ of length $2^{n-1} - 3$. Moreover, according to Lemma 5, $Q_{n-1}^1 - \{q^{(n)}\}$ contains a fault-free hamiltonian path $P[p^{(n)}, v]$ of length $2^{n-1} - 2$. Therefore, the desired fault-free path $P[u,v]$ can be constructed as $\langle u, P[u,q], q, q^{(n)}, p, p^{(n)}, P[p^{(n)}, v], v \rangle$ of length $l = (2^{n-1} - 3) + 3 + (2^{n-1} - 2) = 2^n - 2$ (see Figure 5(b)).

Case 2: $h(u,v)$ is even. That is, u and v are in the same partite set. For the parity of f, we further consider two subcases.
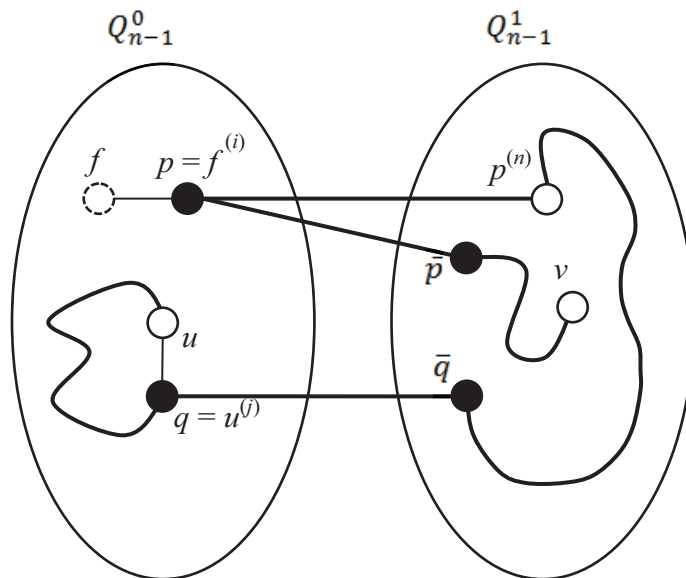
Figure 6: An illustration of Case 2.1 in the proof of Theorem 2

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Case 2.1: f and u are in the same partite set, i.e., $h(f,u)$ is even.

Let $p = f^{(i)}$ be a neighbor of f in Q_{n-1}^0, where $1 \le i \le n-1$, such that $p^{(n)} \ne v$. In addition, let $q = u^{(j)}$, where $1 \le j \ne i \le n-1$, such that $q \ne p$. According to Lemma 6, $Q_{n-1}^0 - \{f, p\}$ contains a fault-free path $P[u,q]$ of length $2^{n-1} - 3$. Moreover, according to Lemma 2, Q_{n-1}^1 contains two node-disjoint paths $P[\bar{q}, p^{(n)}]$ and $P[\bar{p}, v]$ such that $V(P[\bar{q}, p^{(n)}]) \cup V(P[\bar{p}, v]) = V(Q_{n-1}^1)$ and thus $\left| P[\bar{q}, p^{(n)}] \right| + \left| P[\bar{p}, v] \right| = 2^{n-1} - 2$. Therefore, the desired fault-free path $P[u,v]$ can be constructed as

$\langle u, \quad P[u,q], \quad q, \quad \bar{q}, \quad P[\bar{q}, \quad p^{(n)}], \quad p^{(n)}, \quad p, \quad \bar{p}, \quad P[\bar{p}, \quad v], \quad v \rangle$ of length $l = (2^{n-1} - 3) + 1 + (2^{n-1} - 2) + 2 = 2^n - 2$ (see Figure 6).

Case 2.2: f and u are in different partite sets, i.e., $h(f,u)$ is odd.

Let $p = f^{(i)}$ be a neighbor of f in Q_{n-1}^0, where $1 \le i \le n-1$, such that $p \ne u$ and $\bar{p} \ne v$. In addition, let $q = u^{(j)}$ be a neighbor of u in Q_{n-1}^0, where $1 \le j \ne i \le n-1$, such that $q \ne f$. Since $p^{(n)}$ and $\bar{q}$ are in the same partite set, we further consider the following two subcases.

(a)

(b)
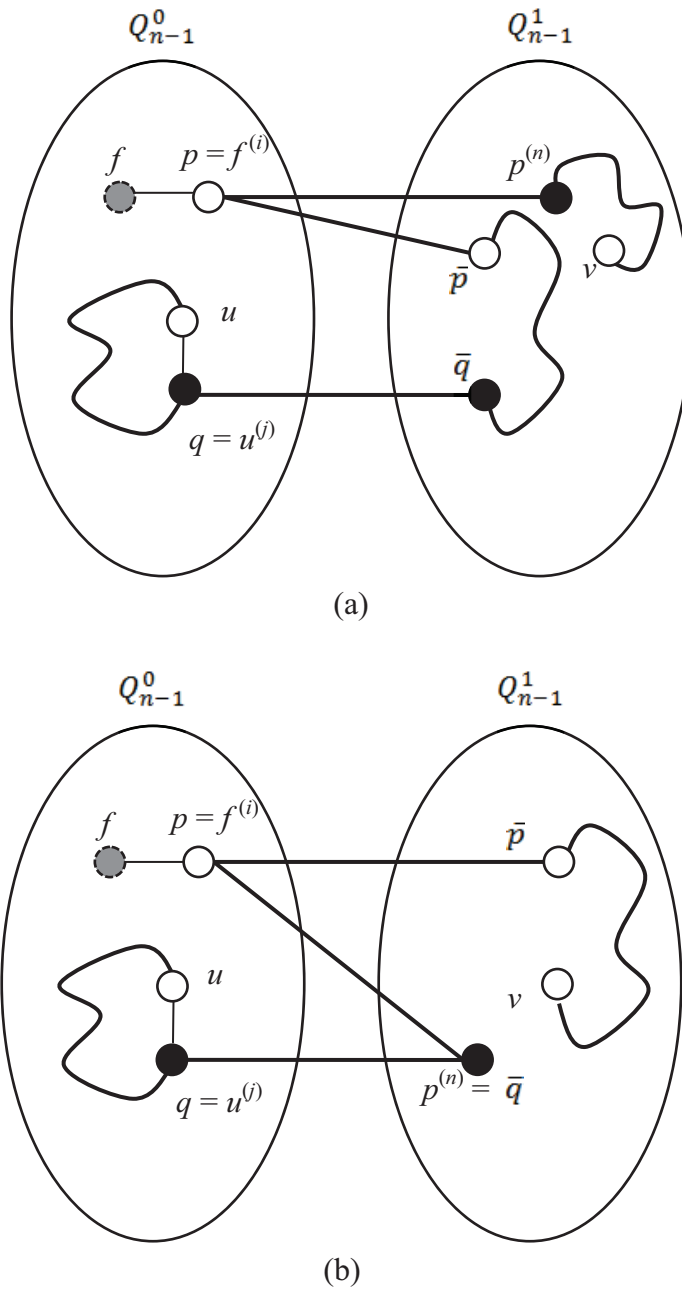
Figure 7: An illustration of Case 2.2 in the proof of Theorem 2

Case 2.2.1: $p^{(n)} \neq \bar{q}$.

According to Lemma 6, $Q^0_{n-1} - \{f, p\}$ contains a fault-free path $P[u, q]$ of length $2^{n-1} - 3$. Moreover, according to Lemma 2, Q^1_{n-1} contains two node-disjoint paths $P[\bar{q}, \bar{p}]$ and

$P[p^{(n)}, v]$ such that $V(P[\bar{q}, \bar{p}]) \cup V(P[p^{(n)}, v]) = V(Q_{n-1}^1)$ and thus $\left|P[\bar{q}, \bar{p}]\right| + \left|P[p^n, v]\right| = 2^{n-1} - 2$. Therefore, the desired fault-free path $P[u, v]$ can be constructed as $\langle u, P[u,q], q, \bar{q}, P[\bar{q}, \bar{p}], \bar{p}, p, p^{(n)}, P[p^{(n)}, v], v \rangle$ of length $l = (2^{n-1} - 3) + 1 + (2^{n-1} - 2) + 2 = 2^n - 2$ (see Figure 7(a)).

Case 2.2.2: $p^{(n)} = \bar{q}$.

According to Lemma 6, $Q_{n-1}^0 - \{f, p\}$ contains a fault-free path $P[u, q]$ of length $2^{n-1} - 3$. Moreover, according to Lemma 5, $Q_{n-1}^1 - \{\bar{q}\}$ contains a fault-free hamiltonian path $P[\bar{p}, v]$ of length $2^{n-1} - 2$. Therefore, the desired fault-free path $P[u, v]$ can be constructed as $\langle u, P[u,q], q, \bar{q}, p, \bar{p}, P[\bar{p}, v], v \rangle$ of length $l = (2^{n-1} - 3) + 3 + (2^{n-1} - 2) = 2^n - 2$ (see Figure 7(b)).

By combining the above cases, we complete the proof. **Q.E.D.**

CONCLUDING REMARKS

Fault tolerant is an important research topic in the area of the multi-process computer systems, and many studies have focus on the vertex-fault tolerant properties of some specific networks. In this paper, we extend Chen's result [1] to obtain two further fault-tolerant properties about embedding fault-free paths in a faulty folded hypercube as follows: (1) $FQ_n - \{f\}$ contains a fault-free path $P[u, v]$ of every length l with $d_{FQ_n}(u, v) \le l \le 2^n - 3$ and $2 | l - d_{FQ_n}(u, v)$, where $n \ge 2$; (2) $FQ_n - \{f\}$ contains a fault-free path $P[u, v]$ of every length l with $n - 1 \le l \le 2^n - 2$, where $n \ge 2$ is even.

REFERENCES

1. Chen, X.-B. (2009) 'Some results on topological properties of folded hypercubes', *Information Processing Letters*, Vol. 109, pp.395–399.
2. EI-Amawy, A. and Latifi, S. (1991) 'Properties and performance of folded hypercubes', *IEEE Transactions on Parallel and Distributed Systems*, Vol. 2(1), pp.31–42.
3. Esfahanian, A. H., Ni, L. M. and Sagan, B. E. (1991) 'The twisted n-cube with application to multiprocessing', *IEEE Transactions on Computers*, Vol. 40, pp.88.
4. Fang, J.-F (2007) 'The biconnectivity and *m*-panconnectivity of the folded hypercube', *Theoretical Computer Science*, Vol. 385(1-3), pp.286–300.
5. Fu, J.-S (2003) 'Fault-tolerant cycle embedding in the hypercube', *Parallel Computing*, Vol. 29(6), pp.821–832.

6. Fu, J.-S (2008) 'Fault-free cycles in folded hypercubes with more faulty elements', *Information Processing Letters*, Vol. 108(5), pp.261–263.

7. Hsieh, S.-Y. (2006) 'Fault-tolerant cycle embedding in the hypercube with more both vertices and faulty edges', *Patallel Computing*, Vol. 32(1), pp.84–91.

8. Hsieh, S.-Y. (2008) 'Some edge-fault-tolerant properties of the folded hypercube', *Networks*, Vol. 51(2), pp.92–101.

9. Hsieh, S.-Y. (2008) 'A note on cycle embedding in folded hypercubes with faulty elements', *Information Processing Letters*, Vol. 108(2), pp.81.

10. Hsieh , S.-Y. and Kuo,C.-N. (2007) 'Hamiltonian-connectivity and strongly Hamiltonian-laceability of folded hypercubes', *Computers & Mathematics with Applications*, Vol. 53(7), pp.1040–1044.

11. Hsieh, S.-Y., Kuo, C.-N. and Chou, H.-H. (2009) 'A futher result on fault-free cycles in faulty folded hypercubes', *Information Processing Letters*, Vol. 110(2), pp.41–43.

12. Hsieh, S.-Y., Kuo, C.-N. and Huang, H.-L. (2009) '1-vertex-fault-tolerant cycles embedding on folded hypercubes', *Discrete Applied Mathematics*, Vol. 157(14), pp.3094–3098.

13. Kuo , C.-N. and Hsieh, S.-Y. (2010) 'Pancyclicity and bipancyclicity of conditional faulty folded hypercubes', *Information Sciences*, Vol. 180(15), pp.2904–2914.

14. Kuo, C.-N., Chou, H.-H., Chang, N.-W. and Hsieh, S.-Y. (2013) 'Fault-tolerant path embedding in folded hypercubes with both node and edge faults', *Theoretical Computer Science*, Vol. 574, pp.82–91.

15. Latifi, S., Zheng, S.-Q. and Bagherzadeh, N. (1992) 'Optimal ring embedding in hypercubes with faulty links', *Proceedings of the 22nd IEEE International Symposium on Fault-Tolerant Computing (FTCS)*, pp.178–184.

16. Leighton, F. T. (1992) *Introduction to Parallel Algorithms and Architecture: Arrays· Trees· Hypercubes*, Morgan Kaufman, San Mateo, CA, USA.

17. Li, T.-K., Tsai, C.-H., Tan, J. J.-M. and Hsu, L.-H. (2003) 'Bipanconnectivity and edge-fault-tolerant bipancyclicity of hypercubes', *Information Processing Letters*, Vol. 87(2), pp.107–110.

18. Ma, M. (2010) 'The spanning connectivity of folded hypercubes', *Information Sciences*, Vol. 180(17) pp.3373–3379.

19. Ma , M. and Zhu, L. (2011) 'The super connectivity of exchanged hypercubes', *Information Processing Letters*, Vol. 111(8), pp.360–364.

20. Mane, S. A. and Waphare, B. N. (2011) 'Regular connected bipancyclic spanning subgraphs of hypercubes', *Computers and Mathematics with Applications*, Vol. 62(9), pp.3551–3554.

21. Manuel, P. (2011) 'Minimum average congestion of enhanced and augmented hypercubes into complete binary trees', *Discrete Applied Mathematics*, Vol. 159(5), pp.360–366.

22. Mitchem , J. and Schmeichel, E. (1982) 'Pancyclic and bipancyclic graphs - a survey', *Proceedings of First Colorado Symposium on Graphs and Applications*, Boulder, CO, USA.

23. Preparata , F. P. and Vuillemin, J. (1981) 'The cube-connected cycles: A versatile network for parallel computation', *Communication of the ACM*, Vol. 24, pp.300–309.

24. Tsai, C.-H., Tan, J. J.-M., Liang, T. and Hsu, L.-H. (2002) 'Fault-tolerant Hamiltonian laceability of hypercubes', *Information Processing Letters*, Vol. 83, pp.301–306.

25. Tsai, C.-H. (2004) 'Linear array and ring embedding in conditional faulty hypercubes', *Theoretical Computer Science*, Vol. 314, pp.431–443.

26. Tseng, Y.-C. (1996) 'Embedding a ring in a hypercube with both faulty links and faulty nodes', *Information Processing Letters*, Vol. 59(4), pp.217–222.

27. Wang, D. (2001) 'Embedding Hamiltonian cycles into folded hypercubes with faulty links', *Journal of Parallel and Distributed Computing*, Vol. 61, pp.545–564.

28. Xu , J.-M. and Ma, M. (2006) 'Cycles in folded hypercubes', *Applied Mathematics Letters*, Vol. 19, pp.140–145.

29. Xu, J.-M., Ma, M.-J. and Du, Z.-Z. (2006) 'Edge-fault-tolerant properties of hypercubes and folded hypercubes', *Australasian Journal of Combinatorics*, Vol. 35, pp.7–16.

30. Xu, J.-M., Ma, M.-J. and Du, Z.-Z. (2007) 'Edge-fault-tolerant Hamiltonicity of folded hypercubes', *Journal of University of Science and Technology of China*, Vol. 36(3), pp.244–248.

31. Yang, J.-S., Chan, H.-C. and Chang, J.-M. (2011) 'Broadcasting secure messages via optimal independent spanning trees in folded hypercubes', *Discrete Applied Mathematics*, Vol. 159(12), pp.1254–1263.

ANALYSIS FOR THE DETERMINANTS OF FACULTY SALARY USING MULTIPLE REGRESSION

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ABSTRACT

This study investigated how the faculty salary in a college located in the Midwestern USA was impacted by various factors, including faculty members' degree, rank, gender, years since highest degree, and years in current rank. Multiple regression analysis was applied in this study to investigate the comparative importance of these factors on the faculty salary in this college. The result shows that the faculty salary was more influenced by their ranks and the "years in current rank" than by other factors. In addition, both qualitative (i.e. dummy variable) and quantitative ways of treating some of the variables were applied and discussed. The further results showed that different methods for treating the variables of "years in current rank" and "years since highest degree" could lead to different regression results. By comparison, we find that it is more appropriate to treat these two variables as qualitative variables and use dummy variables to represent them. The main determinates for faculty salary were then identified and confirmed with empirical data.

Keywords: Multiple regression analysis, Faculty salary, dummy variable

INTRODUCTION

The study of payment structure in the academic labor market is a complicated area, which may be influenced by various factors. For example, full professors usually earn more than associate professors, and associate professors usually have higher salary than assistant professors. Does faculty's rank (full professor, associate professor, and assistant professor) cause statistically significant difference in faculty salary if the impact of all other factors could be ignored? In addition, gender discrimination is a topic which happens in many occupations. In general, male have a higher salary than female in many occupations since female may need to pay more attention to take good care of the family and thus could only spend limited time on their work. However, with the increasing concern for women's rights in current society, we are curious whether the gender discrimination exists in the academic profession, and if so, how significant is this gender discrimination in academic market. Furthermore, faculty members with different education background may earn different levels of salary. Does a faculty member with a doctoral

degree necessarily earn more than a faculty member with a master degree? Teaching experience is another factor which could have impact on the income of faculty. The variables of "years since highest degree" and "years in current rank" could give us some understanding about faculty's teaching experience.

In this study, we select the faculty salary in a small college located in the Midwestern United States as a sample to illustrate how different factors impact the faculty salary in that college. The factors of interest selected in this study are faculty's degree, rank, gender, years since highest degree and years in current rank. In addition, we are interested in investigating whether all these factors play statistically significant roles in determining faculty salary. Are these factors equally important in determining faculty salary, if not, which play more significant role than others? Furthermore, I will try different methods for handling some factors (i.e. those IV which could be treated as either quantitative or categorical variables), and compare the regression results to see which method is better.

LITERATURE REVIEW

The study of faculty salary could be dated back to the 1970s. The payment structure and compensation system in the academic profession is a very complicated topic which could be influenced by a lot of factors and could be hardly to predict. There were several previous studies (Katz 1973, Schrank 1977, McLaughlin, Smart et al. 1978, Neumann 1979, Rickman 1984, Snyder, Hyer et al. 1994, Barbezat and Hughes 2005, Luna 2006, Martinello 2009) conducted on investigating how different factors influence faculty salary in the academic market. In the study by McLaughlin (McLaughlin, Smart et al. 1978), the salary of faculty was founded to be influenced by eight measurements, including institutional characteristics, geographical characteristics, other institutional characteristics, personal characteristics, productivity, recognition, instructional load, and current time in activities. This study used a data base from 24461 respondents. In another study by Neumann (Neumann 1979), the factors of research performance and seniority for faculties from four different academic disciplines have been addressed for their impacts on the faculty salary. The result reveals that research performance is the main determinants for the faculty salary as compared to the seniority, and seniority is positively correlated with the salary. The research performance was reflected on the article publication and book production. The result also shows that different disciplines emphasizes on different research performance. For instance, chemistry and physics emphasize on article publication. Book publication plays an important role in political science, while sociology emphasized on both article and book publication.

The factor of gender is another important determinant for faculty salary. Several previous studies have addressed the impact of sex. The study by Barbezat and Hughes (Barbezat and Hughes

2005) investigated how different academic institutions, including research institutions, doctoral institutions, comprehensive colleges and universities, and liberal arts colleges, impact the gender pay gap. This study led to the conclusion that sex does contribute to the faculty salary discrimination, with females has lower salary than males. Furthermore, this gender pay gap is directly related to the types of research institutions. Schrank (Schrank 1977) conducted a case study in Canada to investigate the sex discrimination in faculty salaries. Besides sex discrimination, this study also investigated faculty members' age, experience, subject area, rank, administrative duties, and publishing record. Rickman (Rickman 1984) conducted a study in a small teaching university to assess the effect of some explanatory variables (sex, degree, rank, teaching experience, administrative activities, etc) on the faculty salary. This study also demonstrated that sex plays an important role in determining the faculty salary in the academic labor market. In another study by Katz (Katz 1973), the determinants for faculty salaries and promotions were investigated at a large highly ranked public university. The factors addressed in this study included the number of books been published, number of articles published, teaching performance, number of dissertations supervised, number of years since highest degree, sex, etc. This study also came up with the conclusion that female received lower salary than male.

In the previous studies, factors of sex, degree, rank, and experience (or years since highest degree) have been revealed to impact faculty salary at some particular universities. An important factor hasn't been paid so much attention is the "years in current rank". In addition, the "Degree" obtained by the faculty may also be an important factor to influence faculty salary. Previous studies (McLaughlin, Smart et al. 1978, Barbezat and Hughes 2005) also showed that different academic institution could have different faculty salary structure. Thus, this course project aims at investigating how the factors of "Years in current rank, Year since highest degree, Degree (Ph.D or Master), Rank (Assistant Professor/ Associate Professor/Professor), and Gender" impact faculty salary in a small Midwestern college in the United States in the early 1980s.

DATA AND MODEL SPECIFICATION

Faculty salary was demonstrated to be a function of gender, degree, rank, experience, institutional characteristics, etc. Different institutions in different countries may have different salary levels for faculty. There is no a standard model for estimating faculty salary in the world. Even though previous studies have shown that faculty salary could be influenced by several factors, an important factor which has not been paid too much attention to is the "years in current rank". This study is going to address how the variable of "years in current rank" impacts the faculty salary. In addition, even though different factors may have impacts on the faculty salary, we are more curious on what are the most significantly influencing factors. To answer these questions, I used a data set collected from a small college in the United States to investigate how the faculty salary was influenced by different factors, especially the factors of "years in current

rank", "years since highest degree", gender, degree, and rank. Also, the impacts from all these factors will be compared to assess the most important variable. Firstly, I will investigate how these parameters individually impact the faculty salary, and then I will develop an appropriate multiple regression model to estimate the faculty salary based on all these factors in this small college.

A data set of 50 observations were collected for the tenured-track faculty members' salaries from a college in the United States. In this project, in order to estimate the impact of degree (doctorate or master), a dummy variable DD was used to represent the highest degree earned by the faculty member. If DD takes the value of 1, it represents a master degree, while DD has a value of 0 indicating a doctorate degree. There are three ranks for the faculty members in this college. They are assistant professor (Rank 1), associate professor (Rank 2) and full professor (Rank 3). Here, we use two dummy variables to illustrate the influence of rank. DR1 = 1 was used to illustrate the dummy variable of Rank1. When Rank equals to 2 or 3, DR1 equals to 0. On the other hand, DR2 = 1 was used to represent the dummy variable of Rank 2, and DR2 = 0 means the rank is either 1 or 3. Since there are only two categories in Gender, we use one dummy variable of DF to represent female faculty member. DF equals to 1 indicating female faculty, while DF equals to 0 representing male faculty. The variable of "years since highest degree" has a range of 1 to 33 years. For this variable, we could treat it as a quantitative variable, or we could treat it as a categorical variable. In the case of treating it as a categorical variable, two categories will be created. One group is between 1 to 9 years, while the other group ranges from 10 to 33 years. Thus, one dummy variable called "DYDeg1" is sufficient to represent this variable of interest. The last variable is the "years in current rank". Similarly, this variable could be treated as a quantitative variable or a categorical variable. It takes the value between 0 to 19 years. If we are going to treat it as a categorical variable, two groups will be created in this study. One group takes the value of 0 to 9 years, while the other group takes the value between 10 to 19 years. A dummy variable called "DYRank1" will be applied herein. Considering the two different ways for representing the variables of "years since highest degree" and "years in current rank", we are going to try different methods to do the regression analysis. The first method is to treat these two variables as quantitative variables, and the second method is to treat these two as categorical variables and use dummy variables to represent them. Since there are more than 3 exploratory variables in this study, multiple regression analysis will be applied in this study. Thus, the empirical model was illustrated as a multiple regression model ($\mathbf{Y} = \mathbf{X} \cdot \boldsymbol{\beta}$). Specifically, if we use the first method of representation, the model would be in this format (equation 1):

FacultySalary = β_0 + β_1 * (DD) + β_2 * (DR1) + β_3 * (DR2) + β_4 * (DF) + β_5 * (YearInRank) + β_6 * (YearSinceDegree) + ε (1)

If we adopt the second way of representation, the regression model would be in the following form (equation 2):

$$\text{FacultySalary} = \beta_0 + \beta_1 * (DD) + \beta_2 * (DR1) + \beta_3 * (DR2) + \beta_4 * (DF) + \beta_5 * (DYRank1) + \beta_6 * (DYDeg1) + \varepsilon \tag{2}$$

EMPIRICAL RESULTS

The following is a basic statistical summary for those variables in the model. From the summary, we can see that the mean annual salary of these 50 faculty members is 23315.56 dollars, with a standard deviation of 5501.56. The minimum faculty salary is 15000 dollars, while the maximum faculty salary is 38045 dollars. The average years in current rank is 7.02 years, with a standard deviation of 4.95. The minimum year for the faculty in current rank is 0, while the maximum year in the current rank is 19 years. The number of years since the highest degree earned in the faculty pool ranges from 1 year to 33 years, with an average value of 15.62 years and a standard deviation of 10.03. There were 14 female faculty members and 36 male faculty members in total. From all the faculty members, 32 had earned a doctoral degree, while 18 only had a master degree. In general, there were 18 assistant professors, 14 associate professors, and 18 full professors. 8 out of 18 assistant professors are female, 2 out of 14 associate professors are female, and 4 out of 18 full professors are female. In the following sections, we are going to address the influence of each factor on the faculty salary separately and interactively. Table 1 gives some basic descriptive statistics for those variables.

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Technology Innovation and Industrial Management
28th-30th May 2014, Seoul, South Korea

Table 1. Descriptive statistics for variables

variables	obs	sample mean (S.E)	description	source
FacultySalary	50	23315.56 (5501.56)	the annual income for faculty (dollars)	alr3 data library
DD	50	0.64 (0.485)	dummy variable for degree (DD=1 for master)	alr3 data library
DR1	50	0.36 (0.485)	dummy variable for Assistant Professor (Rank1)	alr3 data library
DR2	50	0.28 (0.454)	dummy variable for Associate Professor (Rank2)	alr3 data library
DF	50	0.28 (0.454)	dummy variable for Gender (DF=1 for female)	alr3 data library
DYRank1	50	0.7 (0.463)	dummy variable for Year in Current rank (0-9yr)	alr3 data library
YearInRank	50	7.02 (40947)	the number of years in current rank (0-19yr)	alr3 data library
DYDeg1	50	0.32 (0.471)	dummy variable for Year in Current rank (1-9yr)	alr3 data library
YearSinceDegree	50	15.62 (10.026)	the number of years since highest degree (1-33yr)	alr3 data library

In order to address the impact of faculty degree (doctorate degree and master degree) on their salary in this college, we used a dummy variable DD to represent the influence of degree on the faculty salary. When DD equals to 1, it represents the faculty member with a master degree, and DD equals to 0 indicating that the faculty member has a doctorate degree. Regression analysis was then conducted to see how the salary differ between faculty members with doctorate and master degrees. Here, we find that the average faculty salary for PhD is 24359.22 dollars when DD equals to 0, and the average salary for masters is 22728.5 dollars (24359.22-1630.72). The faculty members with a master degree has an averaged lower salary of 1630.722 dollars than faculty members with a PhD degree. However, since the p-value for this dummy variable "DD" is 0.319, which is larger than 0.1. That means this dummy variable is not statistically significant under a significance level of 0.1, implying that the salary differences between different degrees is not significant. From this regression model, we find that the R-squared is only 0.0207, and the adjusted R-squared is about 0.0003. These low R-squares indicate that the variable of Degree is not sufficient to explain the response variable of faculty salary. This exploratory variable of "degree" only explains about 2 percentage of the data variation in faculty salary. As shown in Table 2-Model 1.

Table 2. Regression models on simple specific variables

FacultySalary	Model 1 Coeff (S.E.)	Model 2 Coeff (S.E.)	Model 3 Coeff (S.E.)	Model 4 Coeff (S.E.)	Model 5 Coeff (S.E.)	Model 6 Coeff (S.E.)	Model 7 Coeff (S.E.)
constant	24359.22*** (1296.57)	28971.06*** (646.20)	24077.17*** (902.84)	17718.94 *** (1110.16)	26771.04 *** (899.46)	18222.96*** (1041.49)	27095.53*** (1278.52)
DD	-1630.72 (1620.71)						
DR1		-11202.39*** (913.87)					
DR2		-5795.13*** (976.97)					
DF			-2720.02 (1706.20)				
DYRank1							-5399.96 *** (1528.12)
YearInRank						725.44 *** (121.68)	
DYDeg1					-6645.16*** (1247.33)		
YearSinceDegree				358.30*** (59.98)			
overall F-statistics	1.01	75.16	2.54	35.68	28.38	35.54	12.49
R-squared	0.0207	0.7618	0.0503	0.4264	0.3716	0.4254	0.2064
Adjusted R-squared	0.0003	0.7517	0.0305	0.4144	0.3585	0.4135	0.1899

(Note: *** means 1% statistical significance level; ** means 5% significance level; and * means 10% significance level)

In this study, since there are three ranks for the faculty in this college, we use two dummy variables to illustrate the influence of rank on the faculty salary. DR1 was used to represent the rank of assistant professor. When DR1 equals to 1, it implies that the faculty is an assistant professor. When DR1 equals to 0, it means that the faculty is not an assistant professor, and he or she could be an associate or full professor. Another dummy variable DR2 was used to illustrate the rank of associate professor. When DR2 equals to 1, this professor is an associate professor. Otherwise, this professor is either an assistant professor or a full professor. When both DR1 and

DR2 equal to 0, it represents a full professor. Thus, two dummy variables are sufficient to represent the three categories of rank. From the following regression output, we find that the average annual salary for a full professor at that time period is 28971.06 dollars, since the constant term for this regression is 28971.06 given DR1 and DR2 both equal to zero. The coefficient of DR1 is -11202.39, indicating that an assistant professor earned a lower salary of 11202.39 dollars than a full professor on average. Thus, the average salary for an assistant professor is 17768.67 (28971.06 - 11202.39) dollars. Comparably, the average annual income for an associate professor is 5795.127 dollars lower than a full professor. The annual salary for an associate professor is 23175.93 (28971.06 - 5795.127) dollars. The corresponding p-values for DR1, DR2, and the constant were about 0.000, which are smaller than 0.01. This indicates that the dummy variables of faculty ranks are statistically significant under significance level of 0.01. For this regression, the R-squared is 0.7618 and the adjusted R-squared is 0.7517. This means that more than 75 percentage of the variation in faculty salary could be explained by the independent variable of faculty rank. The F-statistics test for this regression also shows that the main effect from the variable of rank is significant since the respective p-value is only 0.0000. As shown in Table 2-Model 2.

How does the gender influence the faculty salary in this study, and is there a gender discrimination for the faculty income in this college? To answer these questions, I created a dummy variable called DF. DF equals to 1 indicating female faculty, while DF equals to 0 representing male faculty. The following result was obtained by doing a regression analysis of faculty salary on the dummy variable of DF. The coefficient of DF has a negative sign, implying that the female faculty has a lower annual salary than male faculty. The average annual income for male faculty is 24077.17 dollars as illustrated by the constant term when DF equals to zero. In comparison, the female faculty have an average salary of 21357.15 dollars, which is about 2720.02 dollars lower than the average male faculty in this college. Even though there was some difference between the salary of female and male faculty members in this college, the difference was not statistically significant under significance level of 0.1 since the p-value for this dummy variable is 0.117. This means that even though there was some gender discrimination for the faculty salary in this college, the discrimination is not significant. The R-squared for this regression is only 0.0503, and the adjusted R-squared is 0.0305. Both of these two R-square values are quite small, indicating that the independent variable of "Gender" doesn't explain the data variation very well. Also, the p-value for the F-statistics test is 0.1175, which is larger than 0.1. This F-test also tell us that the main effect of Gender is not significantly influence the response variable of faculty income. Some other factors need to be included in the regression model to explain the response variable of faculty salary. As shown in Table 2-Model 3.

Teaching experience is another factor that may influence faculty salary in this college. A professor with higher teaching experience was expected to have higher salary than a professor

with less teaching experience. In this case study, we used the exploratory variable of "years since highest degree earned" to illustrate teaching experience of faculty member. A larger value of "years since highest degree", the more experience is the professor. From the summary statistics of the variable of "years since highest degree", we find that the minimum years since highest degree earned ranged from 1 to 33 years, with an average of 15.62 years. In this study, we used two ways to explore the influence of ""years since highest degree earned" on the faculty salary. One way is to treat "years since highest degree" as a quantitative variable and use its original value, and the other way is to group "years since highest degree" into different categories and then use dummy variables to represent them. For these two ways of representation of "years since highest degree", regression analysis was applied to address how it impacted the faculty salary. The following regression output is the result from the first way of representation of "yeas since highest degree". Here, we find that the average annual salary for a fresh faculty member with no teaching experience is 17718.94 dollars. The coefficient for the "YearSinceDegree" is 358.2985, which means that one more year's teaching experience would lead the faculty salary to increase for about 358.2985 dollars. The richer the teaching experience, the higher the faculty salary. This is consistent with our expectation. From the F-test for this exploratory variable, we find that "years since highest degree earned" has statistical significant influence on the faculty salary, and this could be reflected by the p-value of this test. The p-value is 0.0000, which is much smaller than 0.01. Thus, the senior the faculty, the higher income he or she would earn. The R-squared is 0.4264 and the adjusted R-squared is 0.4144, which indicates about 41 percentage of the data variation in the faculty salary could be explained by this variable of "years since highest degree". As shown in Table 2-Model 4.

The other way of representing "years since highest degree earned" is to use dummy variable to classify them. The minimum value of "year since highest degree" was 1 year and the maximum value was 33 year. Here, we create two groups of "years since highest degree". One group is "1-9" years and the other one is "10-33" years. All the values of "years since highest degree" for the faculty could be classified into one of these two groups. Since there are only two groups, one dummy variable was sufficient to investigate the impact of this categorical variable. From the following regression output, we find that faculty with less teaching experience (years since highest degree less than 10 years) earned an average annual salary of 6645.157 dollars lower than the faculty with comparable rich teaching experience. The average annual income for the faculty with more than 10 years (including 10 years) teaching experience was 26771.04 dollars. The t-test for this dummy variable of "years since highest degree" is significant since the corresponding p-value is 0.000. This result also indicates that the impact of "years since highest degree" is significant for the faculty salary. This result is consistent with the previous finding from the first method. Similarly, we can find that the F-test is statistical significant with a p-value of 0.0000. The R-squared and adjusted R-square are 0.3716 and 0.3585, respectively. These R-square values are slightly smaller than those obtained from the first method. This makes

sense since the categorical data are more roughly in explaining the data variation in the response variable than the quantitative way of the same exploratory variable, holding others constant. As shown in Table 2-Model 5.

One important factor influencing the faculty salary that has not been paid too much attention to is the "year in current rank". In this study, we are going to address this impact of this factor with regression analysis. From the data, we find that the minimum value of "years in current rank" is zero, and the maximum is 19. Similar as the variable of "years since highest degree", we are going to treat this variable in two different ways. The first way is to treat it as a quantitative variable. The following regression results were obtained by directly doing regression of faculty salary on the number of years in current rank. The result tells us that the main effect of this variable is statistically significant since the F-test is significant as illustrated by the small p-value (0.0000). For a faculty member with zero year in current rank, the average salary is 18222.96 dollars when the other factors are not considered. As the number of years in current rank increases 1 year, the income would increase 725.4412 dollars. The second method is to classify different groups of "years in current rank", and then use dummy variable to address its impact on the faculty salary. In this study, I classify two levels of "years in current rank". The number of years in current rank for one group (level one) is between 0 to 9 years, and the other group (level two) ranges from 10 to 19 years. From the regression result, we find that the average salary for faculty from level two is 27095.53 dollars, while faculty from level one has an average lower salary of 5399.962 dollars than faculty from level two. The difference between these two levels of "years in current rank" is significant, which was reflected by the t-test for this dummy variable. The corresponding p-value is only 0.001, which is smaller than 0.01. Furthermore, the F-test for the main effect of this variable also demonstrate the existence of significant difference between these two levels of "years in current rank". The R-square and the adjusted R-square for this second way of representation are smaller than the first way of representation. This also makes sense. As shown in Table 2-Models 6-7.

In this study, it is more interesting for us to investigate the overall effects from all these factors on the faculty salary since they more or less impact the response variable. Thus, multiple regression analysis was applied to investigate their overall impacts. As previously discussed, there are two ways for representing the variables of "years since highest degree earned" and "years in current rank", we investigate the impact of all these factors in two ways. The first way is to treat these two variables as quantitative variables, and the second way is to treat them as categorical variables. From the regression output of first method, we could get the regression model as shown in equation (3)

FacultySalary = 29129.69 - 1909.364* (DD) - 11306.89*(DR1) - 5807.983*(DR2) + 1255.09* (DF) + 430.0002* (YearInRank) -145.035*(YearSinceDegree) + ε.　　　　　(3)

Proceedings of 2014 International Conference on
Technology Innovation and Industrial Management
28th-30th May 2014, Seoul, South Korea

Besides, Breusch-Pagan LM test was applied to test the heteroskedasticity for this model. The p-value from this heteroskedasticity test was 0.4716, which is larger than 0.1. Thus, the result tells us that the errors are homoscedastic and no correction is needed. However, the results shows that something in this model is different with what we have found previously when we analyzed those coefficients separately. For instance, the sign of the dummy variable "DF" is positive while it was negative when we individually did regression analysis of Faculty salary on DF. In reality, female faculty members earn less than male faculty on average. In addition, the sign of "YearSinceDegree" is negative, which means that a faculty member with more teaching experience would have lower salary. This is contradict with what we have found previously and even the real life. In this regression model, the values of R-squared and adjusted R-squared are 0.8494 and 0.8284, respectively. In this situation, even though the correlation of coefficient is good, the meaning of some coefficients conflicts with theory and reality. Therefore, I conclude that this format of regression equation is not that satisfactory.

The second method is to treat these variables of "years since highest degree earned" and "years in current rank" as categorical variables and then use dummy variables to address their impact on the faculty salary. The regression model obtained from the second method is

$$FacultySalary = 30535.07 - 572.3594 * (DD) - 9732.085 * (DR1) - 5610.873 * (DR2) - 68.06723 * (DF) - 2043.94 * (DYRank1) - 1027.477 * (DYDeg1) + \varepsilon. \qquad (4)$$

Furthermore, Breusch-Pagan LM test was applied to test whether the error terms are homoskedastic for this model. The p-value from this heteroskedasticity test was 0.3257, which is larger than 0.1. We can then conclude that the error structure of this model is homoscedastic and no correction is needed. The regression result tells us that for male (DF = 0), full professor (DR1 = DR2 = 0) with PhD degrees (DD = 0), if their years since highest degree is not less than 10 years (DYDeg1 = 0), and years in current rank is not less than 10 years (DYRank1 = 0), their average annual salary is 30535.07 dollars. The sign for the dummy variable of DF is negative, which means that female faculty members have comparable lower salary than male faculty on average, while the sign for the dummy variable of DYRank1 is negative indicating that less experience in current rank would lead to lower faculty salary. In addition, the output from this regression also reflect that a higher degree leads to more income, higher rank leads to higher salary, and more teaching experience (longer time since highest degree earned) let the faculty member has a higher annual salary. All these results are consistent with the real life. Furthermore, the R-squared and adjusted R-squared are 0.8088 and 0.7821, correspondingly. Thus, this second method of doing the multiple regression analysis is more satisfactory and should be adopted.

Based on the developed regression model, we can then estimate the faculty salary for that college at that period by applying the model in equation (4): FacultySalary = 30535.07 - 572.3594 * (DD) - 9732.085 * (DR1) - 5610.873 * (DR2) - 68.06723 * (DF) - 2043.94 * (DYRank1) - 1027.477 * (DYDeg1) + ε. In addition, from the t-test for all the coefficients of this regression model, we find that the coefficients of DD, DF, and DYDeg1 are not statistically significant under all significance levels (0.01, 0.05, and 0.1). In comparison, these two factors of "Rank" and "Years in current rank" significantly impact the faculty salary in this college under significance level of 0.05. Therefore, we will re-run the regression by only including the terms which are statistically significant, and obtained the reduced form of regression model for the faculty salary as

FacultySalary = 30339.71 - 10381.2* (DR1) - 5580.053* (DR2) - 2463.579* (DYRank1) + ε' (5) This simplified regression model has slightly smaller R-square than the full equation, which is meaningful since it includes less terms. However, its Adjusted R-square is slightly higher than the full equation. The p-value of the Breusch-Pagan LM test was 0.2928, which is larger than 0.1. Thus, the errors terms of this simplified regression equation are homoscedastic and follow LRM's assumption. In this model, we find that the variables of "Years in current rank", along with "Rank" significantly impact the faculty salary in this college. As shown in Table 3.

Table 3. Multiple regression models

FacultySalary	Model 1 Coeff (S.E.)	Model 2 Coeff (S.E.)	Model 3 Coeff (S.E.)
constant	29129.69*** (2042.04)	30535.07*** (1014.72)	30339.71*** (753.62)
DD	-1909.36* (1006.92)	-572.36 (940.19)	
DR1	-11306.89*** (1311.63)	-9732.09*** (1226.49)	-10381.2*** (889.23)
DR2	-5807.98*** (971.25)	-5610.87*** (1055.31)	-5580.05*** (906.81)
DF	1255.09 (880.37)	-68.07 (879.18)	
DYRank1		-2043.94** (925.84)	-2463.58*** (825.77)
YearInRank	430.00*** (94.86)		
DYDeg1		-1027.48 (1265.22)	
YearSinceDegree	-145.04* (74.89)		
overall F-statistics	40.43	30.31	61.49
R-squared	0.8494	0.8088	0.8004
Adjusted R-squared	0.8284	0.7821	0.7874

(Note: *** means 1% statistical significance level; ** means 5% significance level; and * means 10% significance level)

CONCLUSIONS

In this study, the faculty salary from a college located in the Midwestern USA was selected to address how different factors would influence the faculty salary. In addition, we compared different methods of treating the exploratory variables and conclude that this would impact the regression results. By comparing different models results and in combination with the real life, we select the most appropriate model. The results from this study tell us that the faculty were more influenced by their rank and the "years in current rank" than by other factors. In comparison, the influences of gender, degree, and "years since highest degree" were not that significant. This finding is slightly different with what have been found in some other studies (McLaughlin, Smart et al. 1978) (Schrank 1977) (Rickman 1984) (Katz 1973). In addition, different ways for treating the variables of "years in current rank" and "years since highest

degree" demonstrated that treating them as categorical variables and use dummy variables to represent them is more appropriate than treating them as quantitative variables.

The result from this study is specifically obtained from that college at that time period, and it may not be easily applicable to some other institutions since different universities or colleges may have different paying system for their faculty. Even though the data set used in this study is a little bit old, the findings from this study could still provide us some understanding about the comparative importance of all these factors influencing faculty salary for this college.

REFERENCES

1. Barbezat, D. A. and J. W. Hughes (2005). "Salary structure effects and the gender pay gap in academia." Research in Higher Education **46**(6): 621-640.
2. Katz, D. A. (1973). "Faculty salaries, promotions, and productivity at a large university." The American Economic Review **63**(3): 469-477.
3. Luna, A. L. (2006). "Faculty salary equity cases: Combining statistics with the law." The Journal of Higher Education **77**(2): 193-224.
4. Martinello, F. (2009). "Faculty salaries in Ontario: compression, inversion, and the effects of alternative forms of representation." Industrial and Labor Relations Review: 128-145.
5. McLaughlin, G. W., et al. (1978). "Factors which comprise salary." Research in Higher Education **8**(1): 67-82.
6. Neumann, Y. (1979). "Determinants of faculty salary in prestigious versus less-prestigious departments: a comparative study of academic disciplines." Research in Higher Education **10**(3): 221-235.
7. Rickman, B. D. (1984). "Faculty Salaries at a Small University: Does Sex Matter?" Quarterly journal of Business and Economics: 47-57.
8. Schrank, W. E. (1977). "Sex discrimination in faculty salaries: a case study." Canadian Journal of Economics: 411-433.
9. Snyder, J. K., et al. (1994). "Faculty salary equity: Issues and options." Research in Higher Education **35**(1): 1-19.

THE IMPACT OF INFORMATION OVERLOAD ON DECISIONAL MAKINGS OF MNEs: A CULTURE PERSPECTIVE

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ABSTRACT

In this study, we focus on investigating how information overload would lead to supply chain management decision making inefficiency, and how this would further impact the performance of MNE during its global activities. The mechanism for information overload's negative impact on decision making is it could further aggravate uncertainty, and even lead to serious bullwhip effect during global supply chain management process. This study investigates the impact of information overload on MNE performance from a culture perspective since the cognitive behavior of SCMS decision makers in MNE plays a significant role. We find that these two dimensions of culture "uncertainty avoidance levels" and "individualism-collectivism" could interactively influence the impact of information overload on the MNE supply chain decision-making process. In general, the impact is stronger for low uncertainty avoidance countries than high uncertainty avoidance countries, and the impact is stronger for individualism than collectivism. However, the impact of information overload on MNE is not so much different between individualism and collectivism when that country is high uncertainty avoidance in the meanwhile.

Keywords: Supply Chain, MNE, culture, information overload, decision making

INTRODUCTION

In recent years, there has been a lot of discussion and research into the problems in the supply chain decision-making and how decision makers make order decisions to the meet the future demand in so-called newsvendor problems. Much of this research centers around a phenomenon termed the bullwhip effect, which is a problem that affects supply chain

management, bullwhip effect. Forrester (1958) first identified the bullwhip effect and its possible causes, and defines this effect as being a trend of increasing variation as demand changed from the end customer to the various vendors in a supply chain. The bullwhip effect further makes information flow harder to effectively achieve, leading to information distortion, meaning that those highest in the supply chain see increasing fluctuations in their demand information.

More recently, experimental studies on the behavioral causes of the bullwhip effect found the bullwhip effect still exist when its operational causes (e.g., price fluctuations, demand estimation, etc.) are removed (Croson and Donohue, 2006). However, some effective methods were found by the researchers to alleviate the operational causes. For instance, by improving the technology level and using advanced techniques for demand forecasting (Chen et al., 1998) and allocation schemes for capacity management (Cachon and Lariviere, 1999).

Behavioral causes of the bullwhip effect (e.g., individual's problem solving methods) have been much more difficult to mitigate. Croson and Donohue (2006) found that inventory information shared to the upper level members helped to alleviate the behavioral causes by enabling them to anticipate and prepare for fluctuations in inventory needs downstream. However, information sharing did not eliminate the bullwhip effect, and subsequent research has suggested that the benefit of additional information depends to a large degree on the extent to which decision makers feel that they can use quantitative, analytical decision making techniques rather than intuitive heuristics (Haines, Hough and Haines, 2010).

In real world contexts, inventory information sharing is essential to the other members in the supply chain stream for MNE. For example, Nike had a big problem with its inventory management system in the late 1990s. At that time, gaining competitive advantage by converting the supply chain from make-to-sell to make-to-order was Nike's dream. In order to do this, they needed to quickly forecast market changes, so Nike implemented demand-planning software from i2, a major supply chain software vendor. And the inventory information (actual data) from stores is the best predictors of demand rather than the software algorithms by the supply chain expert from Nike. Unfortunately, the system proved to be disastrous for Nike and led to over-ordering of older, less popular styles and under-ordering of hotter, newer styles (Wilson, 2001). Nike acknowledges that their mistake was in relying too much on historical sales data and predictive algorithms (Koch, 2004). Rather than using the i2 system, the managers found it was better to talk with the retailers and seeking consensus about

demand trends than blindly following the output of the system. By talking with the retailers, they all received information faster and more accurately, which meant they all knew the coming trends and could make the right decisions (Koch, 2004).

Information sharing is the way to alleviate the bullwhip effect, but redundant or useless information has not improved decision-making. In the supply chain stream, members from distinct level have different demand for the information. The members could have two categories: high frequency members (use the SCM more) and low frequency members. If gave too many information to the low frequency members to make the decision, the results will be affected by information overload and mislead them to a wrong way. For the high frequency members, they will consider the information they got extremely carefully, and then they will make the better decisions. Hence, they will not only share or provide information to the supply chain members, but also choose appropriate information to the individuals. How the MNEs, which are supply chain enterprises, improve their performance and their competitive advantages given the appropriate information to the supply chain members is the research question that motivate us to write this paper. In this study, we address the MNE supply chain management issue by first discussing the decisional guidance and information overload that can influence the decision-making for MNE operations. Next, we will discuss how culture influences the impact of information overload on the performance of MNE, which are the supply chain enterprises.

THEORETICAL FOUNDATION

Decisional guidance

Decisional guidance in supply chain system for MNE is essential to determine the number of the orders among different subsidiaries in MNE. Silver (1991) defined the decisional guidance as how a decision support system (DSS) enlightens or sways its users. Silver (1991) categorized the decisional guidance in inadvertent and deliberate. If the DSSs designed by the deliberate decisional guidance, the decision makers do not need follow the given direction. The deliberate decisional guidance will have the interaction with the users providing the optional choices to the decision makers. This kind of decisional guidance assists the users with the decision-making concepts and provides the choices and interaction with the system's information processing capability. In contrast, the inadvertent guidance is different from the deliberate guidance. Users may sway their judgments with given inadvertent guidance. Human behavior has the limitation when facing the decision-making. The limitation, we could say the

bias of the users, will lead them to the biased selection. The system designers try to find out when and how such inadvertent guidance will happen, then to avoid such unintended consequences.

Sliver (1991) discussed how system designers provide the guidance and the consequence of the decisional guidance. Useful and informative guidance offers pertinent information that assists the users to the final decisions. The goal is to perform the deliberate decisional guidance to the systems. In recent years, most of the companies based on the supply chain are more and more relying on the supply chain management system (SCMS). This kind of systems could meet the company's growing demand both on the customer side and the provider side. Managers and decision makers in the supply chain are eager to get the informative guidance and the satisfied results from the SCMS. Some companies choose the SCMS developed by the third company and get the technology support and training from them. Others may hire professional technologists to research and develop the SCMS embedded into their existed ERP system. The quality of the SCMS will be essential to the supply chain decision-making. How the system designers provide the guidance in the system? The designers should focus on how to avoid the inadvertent guidance occurred in the system and make the deliberate guidance interacting with the decision makers to lead a final decision. For example, the decision makers in the supply chain company use the SCMS to help them predict the order number and place the order by their decisions.

The system may remember the previous selections of the users and foster them make the decision by their habits. This consequence (Silver, 1991) may indicate that the user selected the options and made the acceptable results at the first time, the next time they meet the same options they may choose the same relying on their habits. The cognitive behavior is the one of the causes for the bullwhip effects in supply chain for MNE. As human being, all have the limitation of the cognitive behavior and are used to make decision depend on their habits. Especially for MNE, the decision makers come from different culture background may have very different cognitive behaviors given the same amount of information. Once the results are acceptable, people may repeatedly choose the same approach to reach the goal. Another cause for the bullwhip effects is the operational issue. For instance, the company launched the SCMS recently and provided training to the users who will make the decision in the supply chain management. Inevitably, the users may have the operational fault using this system and this would directly affect the supply chain. Their decisions are not their will and the bullwhip effect will be occurred. The cognitive behavior and operational both would result the bullwhip effect

and the companies would suffer the losses by those issues.

The SCMS should generate the report for evaluating the results by weeks, or bi-weeks. Through the evaluation, managers or decision makers could get benefit from the report and make the adjustments for the next time, which is a path to avoid the behavior problem. At the same time, the feedback from the decision makers would also offer the suggestions to modify the system mechanism. When the system is designed, it may potentially have some inadvertent information given to the users. During the use of the system, timely feedbacks from the users are the pillars for the system. The purpose for the system is to make the operation and management more efficient while the system designed by human being still have the drawback from the human behavior. Even though the guidance in the system is designed seems perfectly and still need the feedback from the users to improve the algorithm and mechanism of the system. If the third company develops the system, the problem will be enhanced. More communications needed, and the modification time of the system may double while the operation still continues. The designers try to avoid the inadvertent guidance occurred in the system and offer the deliberate guidance to the users to make sure the decision is acceptable or good. Here, we find that human behaviors play an important role in the decision making for the supply chain management. Based on this, during the supply chain management process of a multinational enterprise, decision makers from different culture background may have different cognitive behaviors and the corresponding different activities, which may in turn impact the MNE performance.

Cachon and Fisher (2000) stated that information technology allows firms to share demand and inventory data quickly and inexpensively. In contract to the traditional supply chain inventory management, the orders are the only information shared between companies. The deliberate guidance is offered in the SCMS and helps the decision makers to place the order. The members in the supply chain management, including suppliers, retailers, customers, use the shared information in the system to get the better decision and make more profit. The SCMS share the information and interact with the users to let them make the better decisions. The better decision should be considered as the minimum cost for the holding inventory and minimum penalties from back-order. Cachon and Fisher (2000) suggested that the good SCMS should focus on accelerating and smoothing the physical flow of goods through a supply chain rather than expanding the flow of information.

The information technology plays the important role in information exploration era. Silver (1991) contributed the decisional guidance to the DSS. However, Silver's (1991) suggestion about the deliberate guidance somewhat has limitation now. It does not doubt that suggestion is useful and valuable for the 20 century 90s. In nowadays, decisional guidance might overload users with information, making the system more difficult and time-consuming to use. Similarly, the guidance mechanisms may themselves make the system more complex, hence, more difficult to learn and operate.

Information overload

There is the possibility that so much guidance might lead to the information overload. In the simple expression, the term "information overload" is receiving too much information. The performance of the decision makers is related to the amount of information they have. Eppler & Mengis (2004) indicated that the researchers across the various disciplines have found the performance of the decision makers correlates positively with the amount of information they receive and up to a certain point. If the information given is below that point, the decision makers do not have enough information to generate the results, such as the traditional supply chain management. The decision makers may rely more on their prior acceptable results and the process from experiences. The cognitive behavior issue would be emerged in this kind of situation. Considering that cognitive behavior of decision makers play a significant role in the global supply chain for MNE, decision makers (e.g. managers) from different countries may form various cognitive behavior, and culture could be a key factor to influence this cognitive process. On the other hand, if the information they receive is beyond that point, the performance of them will decline rapidly (Chewning and Harrell, 1990). Also, the heavy information load become the burden and misdirects the decision makers, affect their ability to judge and set priorities (Schick el al., 1990). There is an inversed U-shape for the decision accuracy and the information load, as indicated in figure 1.
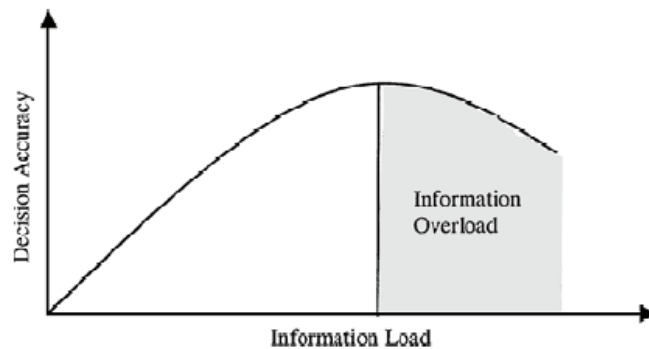
Figure 1 The concepts of Information Overload Capacity

The deliberate SCMS provides users detailed information and may have the problem of information overload. The users are different individual by individual; they have different experience and different frequency to use the system. For example, the infrequent users may require more guidance to make the decision (Silver, 1991). Also, individuals from different culture background may have different cognitive behaviors. The causes of information overload are categorized for two main reasons: organizational and interpersonal levels (Eppler and Mengis, 2004). In SCMS, the two reasons are still the causes for the decision-making. The information (its quality, quantity, intensity, etc.) is the source of the company and decision makers. The processing information capability of the individual, such as receiving and processing, is included in the interpersonal levels. During the daily activities of MNE, either the organizational or the interpersonal reasons could impact the supply chain management for MNE. If SCMS is designed or requested by the company or organization itself, specifically for MNE, so the mechanism issue and information technology the system used are referred to the organization (i.e. MNE).

The information overload would have some effects for the decision makers and even to the organizational operations. First of all, the more information the managers encounter, the more stress they will have since they all have limited capacity to deal with information. They need process too much information and they may loose their judgments when they are under the stress. The managers may dissatisfy the work and then their decision made inefficiently. Secondly, the information overload will bring some negative consequence to the supply chain based company or organization. Information overload may further causes bullwhip effect for supply chain management for MNE and reduce its efficiency and even its profitability. The resource will be wasted caused by the information overload. Another consequence is losing the

advantages for competition for MNE.

For a multinational cooperation, the SCMS aims to improve the work efficiency and competitive advantage in different counties with various culture, while the guidance may be deliberate or inadvertent. In the presence of the information overload, even the deliberate guidance is provided and eliminates the inadvertent guidance from the SCMS, there still exist the possibility to cause the improper decisions. So, not only needs SCMS deliberate guidance, but also need consider the information overload issue to avoid the negative consequence. Preventing the information overload should be initiated with the culture of organization (Rajabzadeh, Nejadirani, Soroodian and Kermani, 2011). Specifically, for MNE, the SCMS need to consider the cross-border culture since MNE needs to handle business from different countries with different culture backgrounds. The corporate culture is influencing the attitudes and the methods of operating and managing, which will determine if the information could be utilized efficiently.

Rajabzadeh el al. (2011) found that the more people participate in the information, the less information overload is possible to emerge since they decreased the repetitive work and provides better and innovative ideas. Thus, considering the various culture backgrounds, MNE could improve its efficiency if it could let more people participate in the information sharing process. MNE is always looking for the lower transportation cost and increased cycle times if sourcing and manufacturing products in foreign countries. Especially for cross border supply chain management, there are the costs that different from the domestic supply chain management. The customs paperwork, possibility of border delays and the transition time are the major issue for MNE. In this particular supply chain, the members from different country with different language and culture may have the communication issue when they are sharing the information with each other. Also, people from the higher uncertainty avoidance country will try to avoid risks when they collect the information and share with other members. On the other hand, people from the lower uncertainty avoidance country may still feel secure and are more acceptable to the excess information. Furthermore, since the culture dimension of individualism-collectivism affect the way people form trust, this may also have impact on the way in which decision makers trust the information they obtained. In consequence, we have the following conceptual model and hypotheses.

CONCEPTUAL MODEL

How information overload impact SCM decision making for MNE?

As discussed above, information overload could cause inefficiency for decision making. For a multinational cooperation with its own supply chain cross-national, its goal is to achieve profit maximization by making optimal decision based on the available information. However, information is like a sword with two edges, too less information is not good, while too much information, especially the inaccurate information (information pollution) is not good either. In this study, we emphasize on how too much information (i.e., information overload) would cause inefficiency for MNE. Since multinational cooperation need to deal with business from different countries, the decision makers for its SCMS may behave very differently given their different culture background. In this study, we will address three hypotheses for MNE during its supply chain management process correspondingly.

Hypothesis 1: **The impact of information overload on SCM decision making for MNE is stronger for countries with relatively lower uncertainty avoidance levels than for countries with relatively high uncertainty avoidance levels.**

Information overload could further aggravate uncertainty that could then lead to inefficiency in decision-making. Given limited cognitive processing capacity for the decision makers, too much information could mislead them and then yield a lower-quality decision. The Phenomenon of "Buridan's Ass" is one classical example of this situation. There are some variations inherent in the supply chain model. In the study by Gilbert (Gilbert 2005) , the supply chain model was demonstrated by Autoregressive Integrated Moving Average (ARIMA) time-series models. Specifically, the demand model was expressed as

$$z_t = \mu + \phi_1(z_{t-1} - \mu) + \phi_2(z_{t-2} - \mu) + \cdots + \phi_p(z_{t-p} - \mu) + a_t - \theta_1 a_{t-1} - \theta_2 a_{t-2} - \ldots - \theta_q a_{t-q}$$

$$w_t \sim N(0, \sigma^2)$$

In this model, the demand was assumed to be a linear function of past demand and past random shocks plus an error term (a_t) at current period, which is the white noise term. From the ARIMA models, we could find that noise (or uncertainty) plays a significant role in the supply chain model. Information could lead decision makers experience supply chain uncertainty in several ways. For instance, in order to estimate future system states, decision makers need to have information on the environment and current supply chain state. Also, decision makers should

have enough information processing capabilities to process information on the environment and supply chain state, etc. However, too much information, especially misleading information, could make decision makers to make poor decisions (Schick, Gordon et al., 1990). Thus, information overload is a big challenge to the decision makers' limited information processing capacity, which could in turn enlarge the uncertainty of the decision-making. This kind of uncertainty may aggregate along the supply chain up to the upstream, and lead to inefficient production and management. The information processing capability by human, especially the manager, plays a significant role when facing information overload issues. Under the background of multinational enterprise activities, the reaction of human being on information overload could be very different concerning their different culture backgrounds since human being is the information processor. Information overload could increase the risk of multinational enterprise activities by increasing the uncertainty in the decision making process. Uncertainty may take the form of high variability in demand, process or supply, which in turn creates problems in planning, scheduling and control.

National culture could have significant impact on decision makers' treatment of uncertainty in the supply chain management of multinational enterprise (MNE). How decision makers deal with the information overload phenomenon is directly related to their uncertainty avoidance level, which reflects a society's tolerance for uncertainty and risk. According to the cultural framework by Hofstede (Hofstede, 1983), uncertainty avoidance is one of the four important dimensions in national culture. Uncertainty avoidance reflects the willingness of people to accept risk or uncertainty. "Weak uncertainty avoidance" societies are those societies in which people tend to feel relatively secure, and they accept and feel comfortable in changeable environments. Comparably, people in "strong uncertainty avoidance" societies are more conservative and less likely to take risk or uncertainty. As mentioned before, information overload could lead to inefficiency and higher uncertainty in decision-making process for decision makers. Since multinational enterprise deals with business in more than one country, decision makers from different countries or different culture background could have various uncertainty avoidance tendencies. Decision makers from "weak uncertainty avoidance" society may still feel comfortable and secure when they face too much information, which could be a similar situation that "weak uncertainty avoidance" people are more comfortable for internet shopping as discussed by Lim (Lim, Leung et al., 2004). In this circumstance, they may prefer to take more risk or uncertainty when they are exposed to too much inefficient or inaccurate information, and herein higher probability for dysfunctional performance. If this happens, the risks from information overload are more likely to influence the decision making

for the supply chain management in multinational corporations. However, for those decision makers from "strong uncertainty avoidance" countries, they prefer to avoid risk, and are more conservative and less likely to be influenced by the misleading information. Therefore, we hypothesize that the impact of information overload on SCM decision making is stronger for countries with relatively lower uncertainty avoidance levels than for countries with relatively high uncertainty avoidance levels.

***Hypothesis 2*: The impact of information overload on SCM decision making for MNE is stronger for individualist than for collectivist countries.**

In the cultural framework by Hofstede (Hofstede, 1983), another important dimension of cultural framework is labeled as "individualism versus collectivism". This culture dimension describes the relation between an individual and his or her surrounding fellow individuals. The study by Lim (Lim, Leung et al. 2004) defined culture as a set of values, attitudes, beliefs and norms within individuals which could shape their cognitions, affect, and motivations, and he also mentioned that individualism-collectivism could affect the way people form trust (Doney, Cannon et al. 1998), which could further influence their willingness to trust the information they obtained. In the study by Huff (Huff and Kelley 2003), national culture was revealed to influence the tendency of individuals and organizations to form trust in the global market. People from individualist countries have a loose ties between individuals, while people from collectivist countries have a tight ties between individuals. Huff found that collectivist people tend to trust in-group than external partners, while individualist people have higher average level of trust for the external partners than collectivist people would have. In the study by Lim (Lim, Leung et al. 2004), collectivist people are demonstrated to be more group-focus, while in individualist people are more self-focus. In addition, Doney (Doney, Cannon et al. 1998) pointed out that people from collectivist culture are more likely to form trust through transference process, while individualist people tend to form trust by calculative process.

With the rapid growth of information technology and Internet, more and more people rely on Web to conduct their own research. Internet could be an important information source for decision makers from a multinational enterprise. Since the information from the Internet is comparably a new source for information and it is difficult to form predictive trust based on previous experience, decision makers from collectivist culture may be less likely to form trust. In comparison, decision makers from individualist culture background are more likely to be influenced by external information and thus the probability to be influenced by misleading

information is higher than collectivist people. In the present global market, decision makers' differences in decision-making may account for much of the order variation in supply chain setting, which would further influence the multinational business activities. In front of the massive external information, especially the "information pollution" (i.e. inaccurate information), the decision makers from the collectivist culture are less likely to be influenced than individualist people. Thus, we hypothesize that the impact of information overload on SCM decision making is stronger for individualist than for collectivist countries.

***Hypothesis 3*: For countries with relatively high uncertainty avoidance, the impact of information overload on SCM decision-making process of MNE is not so much different between individualism and collectivism. For countries with relatively low uncertainty avoidance, the impact of information overload on decision makers is still stronger for individualist than for collectivist countries. (Interaction effect)**

The effects of uncertainty avoidance and individualism-collectivism are not independent with each other. Many studies (Lynn and Martin 1995, De Mooij 2009) have demonstrated the strong correlation between these two cultural dimensions. For example, Lim et al. (Lim, Leung et al. 2004) found that uncertainty avoidance and individualism-collectivism interactively influence the internet shopping adoption. In our study, we investigate the interaction effect of these two culture dimensions on the impact of information overload on decision makers during MNE supply chain management activities. As previously mentioned, people in individualist culture are more likely to form trust from the external information source than collectivist people. However, if the information is too risky and go beyond the decision makers' tolerance level, they may choose not to trust the information they obtain. The lower the tolerance level (i.e. higher uncertainty avoidance level) the decision makers have, the smaller the likelihood that they would trust the information no matter whether they are individualist or collectivist. Since people in high uncertainty avoidance cultures show a strong resistance to change (Kale and Barnes 1992), and they are less likely to be influenced by the external information. Therefore, the influence of information overload doesn't influence so much on the decision making of people with high uncertainty avoidance level. Here, we hypothesize that for people with relatively high uncertainty avoidance level, individualism-collectivism doesn't play an important role on the impact of information overload on SCM decision-making process.

On the other hand, decision makers with a high risk tolerance level (i.e. low uncertainty tolerance level) are more likely to form trust for external information (Hofstede 1983, Doney,

Cannon et al. 1998), which in turn are more likely to be impacted by information overload effect. Too much external information is not so appealing to collectivist decision makers since it is hard for them to form predictive trust from previous experience (Doney, Cannon et al. 1998). However, individualist decision makers form trust through a calculative process. As far as the associated uncertainty or risk is lower than the potential benefit for the information, they would choose to trust the information and make supply chain decisions based on the available information. Thus, they are more likely to be impacted by the information overload effect. Here, we found that uncertainty avoidance and individualism-collectivism interactively impact the decision making process in the global supply chain management. We hypothesize that for countries with relatively low uncertainty avoidance, the influence of individualism-collectivism is significant on the impact of information overload on decision makers. And then, we have the following model (Figure 2) to explain the relationship between the uncertainty avoidance and individualism-collectivism.
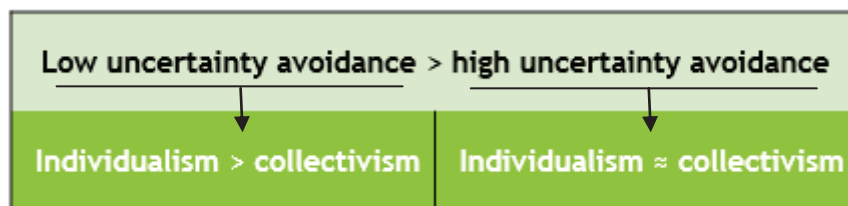
Figure 2 The impact of information overload on MNE supply chain decision maker (an culture perspective)

CONCLUSIONS

Based on the discussion above, an appropriate supply chain management strategy is critical for the decision makers in MNE to make optimal decisions, which could in turn lead to high efficiency and profitability of MNE. While information load plays like a two side sword, lack of information or too much information (specifically inaccurate information) is harmful for decision-making process. In this study, we focus on investigating how information overload would lead to supply chain management decision making inefficiency, and how this would further impact the performance of MNE during its global activities. The mechanism for information overload's negative impact on decision making is it could further aggravate uncertainty, and even lead to serious bullwhip effect during global supply chain management process. As discussed previously, the cognitive behavior is one key cause for the bullwhip effects in supply chain. Considering MNE need to do global business, and the cognitive

behaviors of it is decision makers could significantly impact MNE decision making. Given the same information, decision makers from different counties may have very different cognitive behaviors, and then different decisions will be made. Different decisions in the supply chain management would then cause very different operation outcomes for MNE. Some may be very optimal and lead to great financial performance of MNE, while other decisions may cause inefficient operation of MNE or it may even cause the MNE in a very dangerous situation, for instance break in the fund-chain.

As mentioned, information overload could lead to bullwhip effect in SCMS decision-making process, and this impact could be significant. In this work, we investigate how information overload could cause inefficient SCMS decision-making, and later on poor MNE performance from a culture perspective. Given the fact that MNE need to deal with global business, its supply chain management process is much complicated than a single domestic firm. Globalization means MNE need to handle business of people in different culture background. Human cognitive behaviors, especially those from decision makers in various subsidiaries of MNE, significantly influence the overall decision-making process for MNE. Information overload could impact the MNE performance by influencing its decision makers in host and home countries. During this process, culture in the host or home countries is an important factor we need to take into account.

In this study, we find that the impact of information overload on SCM decision making for MNE is stronger for countries with relatively lower uncertainty avoidance levels than for countries with relatively high uncertainty avoidance levels. In general, the impact of information overload on SCM decision making for MNE is stronger for individualist than for collectivist countries. Furthermore, the impact of "uncertainty avoidance level" and "individualism-collectivism" are not independent with each other, instead, they always act together to influence the behaviors of decision makers of MNE. There is an interaction effect. For countries with relatively high uncertainty avoidance, the impact of information overload on SCM decision-making process of MNE is not so much different between individualism and collectivism. For countries with relatively low uncertainty avoidance, the impact of information overload on decision makers is still stronger for individualist than for collectivist countries.

REFERENCES

1. Chen, F. (1998), "Echelon reorder points, installation reorder points, and the value of centralized demand information", *Management Science*, 44: S221–S234.

2. Cachon, G. P., & Fisher, M. (2000), "Supply chain inventory management and the value of shared information", *Management science*, 46(8): 1032-1048.

3. Cachon, G., M. Lariviere. (1999), "Capacity choice and allocation: Strategic behavior and supply chain performance", *Management Science*, 45: 1091–1108.

4. Chewning, E. C., Jr., and Harrell, A. M. (1990), "The effect of information load on decision makers' cue utilization levels and decision quality in a financial distress decision task", *Accounting, Organizations and Society*,15:527–542.

5. Croson, R., & Donohue, K. (2006), "Behavioral causes of the bullwhip effect and the observed value of inventory information", *Management Science*, *52*(3): 323-336.

6. Forrester, J. (1958), "Industrial dynamics: A major breakthrough for decision makers", *Harvard Bus. Rev*, 36: 37–66.

7. Kochh,C.(2004),"Nike Rebounds: How (and Why) Nike Recovered from Its Supply Chain Disaster",available at http://www.cio.com/article/32334/Nike_Rebounds_How_and_Why_Nike_Recovered_from_Its_Supply_Chain_Disaster (accessed 3 November 2013).

8. De Mooij, M. (2009), "Global marketing and advertising: Understanding cultural paradoxes", *Sage*.

9. Doney, P. M., et al. (1998), "Understanding the influence of national culture on the development of trust", *Academy of Management Review*, 23(3): 601-620.

10. Eppler, M. J., & Mengis, J. (2004), "The concept of information overload: A review of literature from organization science, accounting, marketing, MIS, and related disciplines", *The Information Society*, 20(5), 325-344.

11. Gilbert, K. (2005), "An ARIMA supply chain model", *Management Science*, 51(2): 305-310.

12. Russell Haines, Jill R. Hough and Douglas Haines. (2010), "Individual and Environmental Impacts on Supply Chain Inventory Management: An Experimental Investigation of Information Availability and Procedural Rationality", *Journal of Business Logistics.* 31(2), 111-128

13. Hofstede, G. (1983), "The cultural relativity of organizational practices and theories", *Journal of International Business Studies*, 14(2): 75-89.

14. Huff, L. and L. Kelley. (2003), "Levels of organizational trust in individualist versus collectivist societies: A seven-nation study", *Organization Science*, 14(1): 81-90.

15. Kale, S. H. and J. W. Barnes. (1992), "Understanding the domain of cross-national buyer-seller interactions", *Journal of International Business Studies*, 101-132.

16. Lim, K. H., et al. (2004), "Is eCommerce boundary-less? Effects of individualism–collectivism and uncertainty avoidance on Internet shopping", *Journal of International Business Studies,* 35(6): 545-559.

17. Lynn, R. and T. Martin. (1995), "National differences for thirty-seven nations in extraversion, neuroticism, psychoticism and economic, demographic and other correlates", *Personality and Individual Differences*, 19(3): 403-406.

18. Rajabzadeh A, Nejadirani F, Soroodian R, Kermani R. Informational Overload; Roots and Consequences. Australian Journal Of Basic & Applied Sciences [serial online]. December 2011;5(12):353-359. Available from: Academic Search Complete, Ipswich, MA. Accessed November 2, 2013.

19. Schick, A. G., et al. (1990). "Information overload: A temporal approach. *Accounting", Organizations and Society*, 15(3): 199-220.

20. Silver, M. S. (1991), "Decisional guidance for computer-based decision support", *MIS Quarterly*, 105-122.

GAINING A MARKET ADVANTAGE ON PROPERTY INSURANCE BY AN ENGINEERING ALGORITHM

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ABSTRACT

Differential advantage can gained in various ways including market segmentation, strong distribution channels, product or service offering, selling approach, geographic location and manufacturing expertise. Finding a differential advantage in the market place is a major management challenge requiring both creative and analytical skills. This paper has dealt with the importance degree calculation of the four main factors which are considered by a property-liability insurance policy buyer in selecting insurer by Analytic Network Process (ANP). These factors include: availability of coverage, cost of coverage, financial stability of insurer, quality and quantity of service offered. As these factors are all interrelated so we utilized ANP model to prioritize them and help decision makers how to allocate their resources in order to increase their market share. In this research we synthesized property and liability insurance buyers' views with experts' perceptions. So providing an analytical algorithm to improve the competitive managerial skills in property or liability insurance market is the core aim of this research. Results from the synthesized limit super matrix revealed that quantity and quality of services offered is the most outstanding alternative amongst the others.

Keywords: ANP, property-liability insurance, selection.

INTRODUCTION

How does one go about deciding which type of insurer is best if needs arises for purchasing different kinds of property or liability policies? There are four main factors (in our research they are considered as our alternatives) to consider in selecting an insurer from the view point of buyer: availability of coverage, cost of coverage, financial solvency and stability of the insurer and quality and quantity of service offered [1]. Rational decision-making is a talent we must encourage if we want to be more effective in implementing our ideas in the real world with its risks and resistance to change. There are two types of decisions the first one is to determine what we prefer the most, known as normative decision-making in these circumstances it is easy to see why we do not wish anything to happen that can undermine the best choice we make. The second one is descriptive decision-making which is how to make a best choice given all the influences in the world around us that can affect the optimality of any choice we make thus if we choose this type as an alternative to the first one we do not want it to be influenced by the other alternative that occur to us later. The first ones are falsifiable statements that attempt to describe the real world as it is and normative ones legislate how things ought to be and can never be proven to be correct and workable, but only disproved with examples of what the recommended failing [2]. In reality how good any choice we make depends on how well we know our alternatives as compared with each other and with others outside the collection being compared so we can rank them as to how good they are. Decision-making involves prioritizing ideas according to the circumstances we face now or might face in the future. A fundamental problem is how to measure intangible criteria and how to interpret them to yield sensible. The ANP is fundamentally a way to measure intangibles factors by using pair wise comparisons with judgments that represent the dominance of one element over another with respect to a property that they share [3]. The ANP has found useful application in decision making which involves numerous intangibles. It is a process of laying out a structure of all essential factors that influence the outcome of a decision. Numerical pair wise comparison judgments are then elicited to express peoples understanding of the importance, performance or likely influence of these elements on the final outcome obtained by synthesizing the priorities derived from different sets of pair wise comparisons and sensitivity analysis is performed in the end to determine the stability of the outcomes to wide perturbations in the judgments [4] .services play an increasingly important role in the I.R.I and also in the global economy and have in fact become more important than goods, services produced by insurance industry accounted for .1% of Gross Domestic Product(GDP)in 2011 and it is to supposed be 1.45%in 2015 [5]. To the best of our knowledge studies of utilizing of ANP to prioritize factors in selection property-liability insurer are so far lacking. The aim of this paper is to fill this gap by examining the ANP utilization in scientifically prioritizing these factors. Our decision to study insurance industry is motivated by some factors: first the insurance industry has experienced an acceptable volume of domestic direct and indirect investment in recent years in Iran, mainly due to new technological

advancements governmental liberalization policies which have created many opportunities for private insurance firms to become active in financial market and more over insurance industry is one of the largest service industry in Iran. The second one is that an insurance policy involves the payment of a premium over long period of time in order to generate a specific type of benefit for the policy holder in the future as a result policy holders are likely to have long-term relationship with their insurance firms and are likely to have a specific interest in the performance of their insurer [6]. So together with the lack of international management research on insurer selecting factors and specially their scientifically prioritization method, make the insurance industry and prioritizing models an interesting service industry to study.

Insurers' selection factors:
A-**availability of coverage (A_1)**: do all insurance companies offer every insurance facility or every type of property or liability coverage? If not , this may narrow the field of choice but if yes, may some insurers not be interested in accepting the proposal at the rate they are allowed to charge because it may not be profitable to the underwriter. In Islamic Republic of Iran (IRI) all the private and state insurance companies which add up to about 30 service firms approximately offer the same property and liability policies and the rates are dictated to them by central insurance, Bimeh Markazi Iran[1], (BMI) although insurance companies are allowed to change some conditions or terms of the policy but it is not of great importance degree from the view of policy holders and could be ignored by them.

B-**cost of coverage (A_2)**: insurance is a service in which the cost must be estimated in advance by the insurer, in these estimates considerable variations among different underwriters may be expected. In some cases excess charges for contingency reserves are returned to the insured under various types of pricing method such as dividends in other cases no premium adjustment is anticipated and the initial premium is fixed. There are three methods of comparing costs:

B.1.direct comparison of gross premium: if the initial premium is fixed and all matters of importance surrounding the transaction are equal it seems clear that the insured select the policy with the lowest price, now days unfortunately in IRI this comparison is very popular among the buyers without paying much attention to the terms of policy so some insurers lower the initial premium and change some conditions of the policy to their own benefits and because of these conditions when the loss occurs the insured will not be completely made up for covered losses.

B.2.comparison of gross premium less estimated dividends: some insurers may deliberately charge a higher premium to allow for contingencies and anticipate returning any excess to their insured group in form of dividend or a premium reduction for the renewal policy. In these

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[1] - Bimeh Markazi Iran (Central Insurance of Iran) was established in 1971 by the Act of Parliament for the purpose of regulating, expanding and guiding Insurance Industry in Iran.

circumstances considering estimated dividend schedules, timing and form of the dividend, should be applied by the insured in deciding whose price is the lowest. In IRI as any type of returning is fixed by BMI so automatically buyers pay no attention to this factor else some specific discounts on some special ceremonies which are provided by insurers unsystematically.

B.3.comparison of operation efficiency: comparing insurers as to their internal operating efficiency (loss and expense ratio and net underwriting profit) in the belief that the most efficient insurer will in long run be the cheapest and best.

C-**financial solvency and stability of the insurer (A_3)**: the main item of interest to one in the purchase of insurance is a guarantee of compensation for a covered loss. If bad financial policies or inadequate premium and poor underwriting standards endanger the insurers' fund that is set aside for losses, the insured may find the insurance policy has been carried for years to no avail. Although the system of state regulation (BMI) over insurance companies guarantee the financial solvency of all the insurers but it should not be automatically assumed by the buyers that the insurer will necessarily exist when the loss occurs so not only the analysis of financial statements should be judged by financial engineers and analysts but also unfortunately in IRI taking other things constant a high percentage of market share is the proof of stability so buyers often pay much attention to this ratio and it is very important to laypersons.

D-**quality and quantity of service offered (A_4)**: the question of service is a vital one in determining whether any saving in insurance cost is actually a net saving or merely a symptom of the fact that certain functions are not being performed by an insurer who offers coverage at lower price. Various studies have suggested that the quality and quantity of services provided by insurers and their agents often do not live up for policyholders expectations. Each insured should consider this factor carefully e.g. a person seeking only a automobile third party liability policy has less need for investigating agency services than a large industrial firm which may find many agencies in it's local large enough to provide sufficient contracts with the insurance market as well as risk management analysis such as loss prevention service.

Major property and liability insurance contracts in IRI.
According to BMI annual report the major property-liability policies include: fire insurance policy, liability, automobile, engineering and transportation policies which are considered in our network as criteria [5].

Fire insurance policy (C_1): The object of fire insurance is compensating from financial and material losses on wealth and property of people, by fire, flood, explosion, earthquake, storm, volcano, lightning, and many other allied risks. There are 3 types of fire insurance:

A) Residential units which consists of : Public plan fire insurance, Home and family comprehensive fire insurance , Ordinary home fire insurance policy , Fire insurance policy for homes with flood and earthquake coverage.

B) Non-industrial centers which consists of: General non-industrial units, Comprehensive shops and retailers units which Cover the followings: Commercial stores, Repair shops, Hospitals, Public places, Office buildings, Real estate,

C) Industrial centers covers: General industries fire insurance, Special plans for industrial units including: Machinery breakdown cover, Business interruption, All risk property policy, Industrial comprehensive policy.

Liability insurance policy (C₂): one of the most serious financial risks covered by insurance is that of loss through legal liability for harm caused others. different types of liability insurance include:

A. Professional Liability Insurances for: Physicians , Medical Centre Owners or Managers, Nurses and Medical Technicians, Engineers, Lawyers , Auditors & Registration Officers , Production & Services Quality Inspectors , Insurance Agents & Brokers , Agriculture Supervisors , Hunters , Rangers & Environment Protectors

B Employer's Liability for Employees

C. Liability of Producers and Sellers of Product

D. Contractual Liability Insurance : International Carriers and Forwarders Convention Liability , Sea, Air, Rail and Land Transit Companies Liability , Combined Carriage (F.B.L) Companies Liability , Liability of Tenant as against Landowner , Liability of Contractors for the Project Owner according to the contract wording.

E. General Liability Policies (GL)

F. Comprehensive Liability General Insurance (CGL)

AUTOMOBILE INSURANCE POLICY (C₃): this policy covers losses from liability, from collision, and from bodily injuries and deaths due to accidents. Measured by premium volume, automobile insurance is by far the largest single segment of all property and liability insurance business in IRI and consists of:

A. Auto Third Party Insurance: covers Financial (Material) Damages and Physical Damages (Death, physical defect or disability and medical expenses).

B. Auto Passenger Insurance: covers, Death, physical defect, medical expenses (On passengers of the insured vehicle).

C. Vehicle Insurance: this policy covers damages on the insured vehicle caused by: Fire, Accident, Theft, Collision, and Overturning.
Some important allied Auto risks are: Theft of vehicle's parts, Breakage of glass, Out of service coverage, Price fluctuation, Natural disasters, Damage caused by chemical materials

ENGINEERING INSURANCE (C_4): it includes different types of insurance policies in the field of Engineering Specialties proceeds to cover physical losses and damages in civil projects, infrastructure and constructional operations and technological industries. The most important ones are as following:

* Contractor All Risk (CAR)
*Erection All Risk (EAR)
*Civil Engineering Completed Risks (CECR)
* Machinery Breakdown (MB)
*MB Loss of Profit (MBLOP)
* Contractor's Plant and Machinery (CPM)
* Deterioration of Stock in Cold storage (DOS)
*Electronic Equipment o Hardware or Software (EE)

TRANSPORTATION INSURANCE (C_5):
Marine cargo insurance: This policy renders different standard Marine Cargo policies to provide covers according to latest insurance world clauses for local and international transportation of goods.

Clause A: The most complete cover which is usually used for the susceptible and damageable goods.

Clause B: This cover is to compensate for risks covered by Clause C in addition to the following perils and risks: Earthquake, volcano or lightning, Entry of sea, lake and river water into means of carriage or place of storage, Total loss of one complete package during loading to or discharging from vessel, Meanwhile, in Clause B cover, usually risks like non-delivery, theft, pilferage, breakage, shortage are added.

Clause C: The condition of this insurance covers the following risks: Fire or Explosion, Vessel or craft being stranded, grounded, sunk or capsized, Land Transit vehicle being overturned or deviated from the line, Collision, Discharge at port of distress, Cargo sacrifice, Jettison.

MARINE HULL AND MACHINERY INSURANCE
It covers for different types of carrier vessels including container or bulk cargo ships, passenger, fishing vessels as well as oil tankers. Hull and Machinery of insured vessels are covered according to the standard international insurance clauses.

AVIATION INSURANCE: Aviation policies are planned to cover risks related to ownership, operation and use, repair and maintenance, as well as sale of the insured aircrafts. Further undertakings are: Hull War insurance, General Liability insurance , Total Loss insurance , Airport Equipments insurance , Hull Franchise insurance , Loss of License insurance (Pilots & Engineers), Production Liability insurance.

Analytic network process (ANP):
The ANP is a mathematical theory that can deal with all kinds of dependence systematically. The ANP has been successfully applied in many fields [7]. ANP has a systematic approach to set priorities and trade-offs among goals and criteria, and also can measure all tangible and intangible criteria in a model.

Many decision problems cannot be structured hierarchically because they involve the interaction and dependence of higher-level elements in a hierarchy on lower-level elements. Not only does the importance of the criteria determine the importance of the alternatives as in a hierarchy, but also the importance of the alternatives themselves determines the importance of the criteria. And also feedback enables us to factor the future into the present to determine what we have to do to attain a desired future. The Analytic Network Process is a generalization of the Analytic Hierarchy Process. The basic structures are networks. Priorities are established in the same way they are in the AHP using pair wise comparisons and judgments. The feedback structure does not have the top-to-bottom form of a hierarchy but it looks more like a network, with cycles connecting its components of elements, and we can no longer call them levels, with loops that connect a component to it [8]. Traditional MCDM methods are based on the additive concept along with the independence assumption, but individual criterion is not always completely independent. For solving the interactions among elements, the analytic network process (ANP) as a relatively new MCDM method was proposed by Saaty [9].

This study involves numbers of pair wise comparisons for deriving the priorities of factors of property-liability insurers' selection. Synthesizing experts' opinions is in compliance with the geometric mean method Buckley [10]. The valuation scales used in the study are those

recommended by saaty [4,9], where 1 is equal importance, 3 moderate importance, 5 is strong importance, 7 is very strong or demonstrated importance, and 9 is extreme importance. Even numbered values will fall in between importance levels. Reciprocal values (e.g. 1/3, 1/5, etc.) mean less importance, even less importance, etc. Saaty proved that for consistent reciprocal matrix, the λ max value is equal to the number of comparisons, or λ max $= n$. A measure of consistency was given, called Consistency Index as deviation or degree of consistency using the following formula [4]. If the value of I.I. Ratio [I.I. $= (\lambda$ max $- n)/ (n-1)$] is smaller or equal to 10%, the inconsistency is acceptable. If the *I*.I. ratio is greater than 10%, the subjective judgment needs to be revised. *n* in the formula denotes the number of elements that have been compared. When λ max $= 0$, the complete consistency exists within judgment procedures and then λ max $= n$. The consistency ratio (I.R.) of I.I. to the mean random consistency index (I.I.R) is expressed as I.R. (I.R. $=$ I.I. / I.I.R) less than 0.1. The outcome of the process above is able to compose an un-weighted super matrix. Its columns contain the priorities derived from the pair wise comparisons of the elements. In an un-weighted super matrix, its columns may not be column stochastic. To obtain a stochastic matrix, i.e., each column sums to one, the blocks of the un-weighted super matrix should be multiplied by the corresponding cluster priority. To derive the overall priorities of elements, this method involves multiplying sub-matrices numerous times in turn, until the columns stabilize and become identical in each block of sub-matrices.

The weighted super matrix can then be raised to limiting powers to calculate the overall priority weights. The ANP employs the limiting process method lim $k\to\infty$ *Wk* of the powers of the super matrix [9; 11; 12; 13]. For synthesizing overall priorities for the alternatives, the un-weighted super matrix requires adjusting in order to keep it column stochastic [14].

RESEARCH METHOD

Our proposed algorithm applying ANP to matrix operations in order to determine the overall priorities of the criteria identified to measure and prioritize insurer selection factors (alternatives) is as the figure follows:

Identify sample element by cluster sampling

↓

Identify criteria and determine their weights by questionnaire

↓

Determine the importance degrees of the factors with respect to each alternatives with a 1–9 scale

↓

Determine the importance degrees of the alternatives with respect to each factor with a 1–9 scale

↓

Determine the overall priorities of the alternatives &criteria

↓

Prioritize alternatives based on the limit super matrix and decision making

Figure 1-Algorithm of factors prioritization by ANP.

The research method is descriptive-survey which has been selected on the basis of the nature of this research. The population of this research includes all the property-liability policy holders who were living in northern Tehran during 2013. Original research using a self-administered questionnaire which was distributed via mail to 129 organizations and 400 policy holders and also 3 insurance experts who were professor assistant of insurance as well as top managers of insurance companies(all of these 3 were returned usable). Out of the 440 questionnaires posted, 310 usable questionnaires were returned, yielding a response rate of 58.60%.Data were analyzed by using super decisions and SPSS software at the two levels of descriptive and analytical statistics. At the level of descriptive statistics, frequency, percentage, mean and standard deviation were used and at the level of analytical statistics dependent t-test, were used to investigate the policy holders' opinions. Sample volume was calculated according to the following formula [15].

$$(1)\quad n = \frac{z^2 \sigma^2}{d^2}$$

Where d is the maximum error, σ^2 is the variance of the assumed population and $Z_{\alpha/2}$ is critical normal deviate for specified reliability1-α

To calculate the variance and reliability 30 questionnaires were distributed among policy holders the variance was equal to .495 and previous studies indicate that desired precision of d=.06, with reliability probability of 1-α=.95 and from critical normal deviate values table we know that Z.25=1.96 thus the required sample size is 529 (rounded) and the reliability was estimated via Cronbach's alpha (85%) by SPSS software.

Our network is shown in figure 2 which contains 4 alternatives, selecting property-liability insurers' factors and five criteria, major property-liability policies, and the goal of the model was to measure the alternatives and prioritize them according to policy holders' opinions synthesized by 3 experts' opinions.
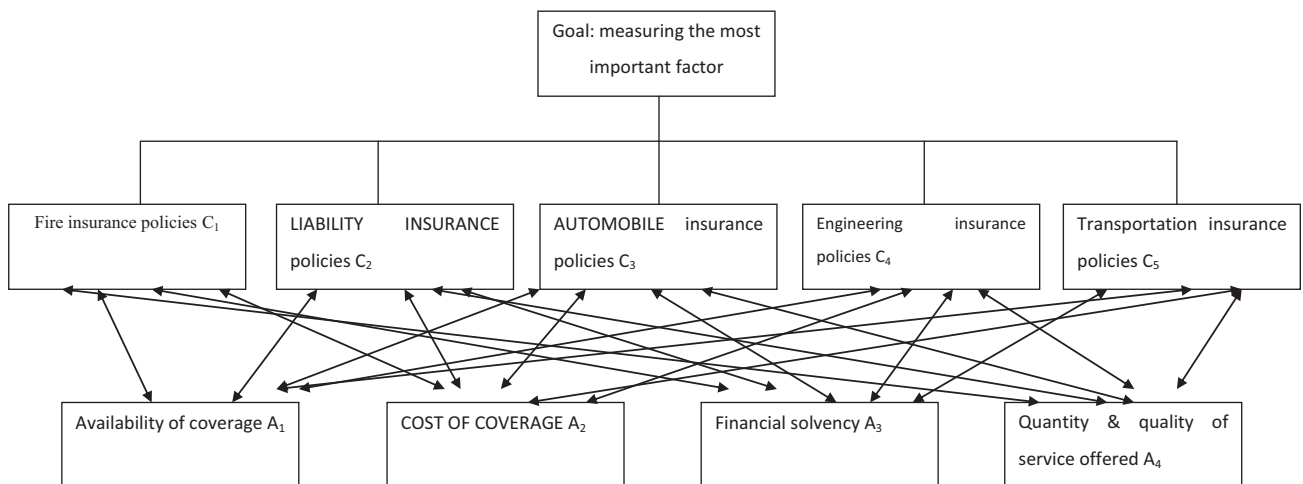
Figure 2, network to measure property-liability insurer selection factors.

The ANP is composed of four major steps:

Step 1: Model construction and problem structuring: The problem should be stated clearly and be decomposed into a rational system, like a network. This network structure can be obtained by decision-makers through brainstorming or other appropriate methods.

Step 2: Pair wise comparison matrices and priority vectors: Similar to the comparisons performed in AHP, pairs of decision elements at each cluster are compared with respect to their importance towards their control criteria. The clusters themselves are also compared with respect to their contribution to the objective. Decision-makers are asked to respond to a series of pair wise comparisons of two elements or two clusters to be evaluated in terms of their contribution to their particular upper level criteria. In addition, interdependencies among elements of a cluster must also be examined pair wise; the influence of each element on other elements can be represented by an eigenvector. The relative importance values are determined with Saaty's 1–9 scale (Table 1), where a score of 1 represents equal importance between the two elements and a

score of 9 indicates the extreme importance of one element (row cluster in the matrix) compared to the other one (column cluster in the matrix) [16].A reciprocal value is assigned to the inverse comparison, that is, a_{ij} ¼ $1=a_{ji}$, where a_{ij} (a_{ji}) denotes the importance of the i_{th} (j_{th}) element. Like with AHP, pair wise comparison in ANP is performed in the framework of a matrix, and a local priority vector can be derived as an estimate of the relative importance associated with the elements (or clusters) being compared by solving the following equation:

$$(2) \quad A \times W = \lambda_{MAX} . W$$

Where A is the matrix of pair-wise comparison, w is the eigenvector, and λ_{max} is the largest eigenvector value of Saaty [1980] proposes several algorithms to approximate w. In this paper, super decision is used to compute the eigenvectors from the pair-wise comparison matrices and to determine the consistency ratios.

Table 1-Saaty's 1–9 scale for AHP preference [9]

Intensity of importance	Definition
1	Equal importance
3	Moderate importance
5	Strong importance
7	Very strong importance
9	Absolute importance
2,4,6,8	Intermediate importance
Reciprocal of above non-zero numbers	If activity i has one of the above non-zero numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i

 Each matrix should be normalized by the following formula [8]:

$$(3) \quad a_{ij} = \frac{a_{ij}}{\sum_{i=1}^{m} a_{ij}}$$

The consistency index we chose is as below [8]:

$$I.I. = \frac{\lambda_{MAX} - n}{n-1}$$
(4)

And the rate of inconsistency is calculated according to the following formula:

$$I.R. = \frac{I.I}{I.I.R}$$
(5)

Where *I.I.R random index* is chosen from random index table, is shown in table 2.

Table 2 Random index table [8]

Order	1	2	3	4	5	6	7	8	9
I.I.R	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45

Step 3: Super matrix formation: The super matrix concept is similar to the Markov chain process [9]. To obtain global priorities in a system with interdependent influences, the local priority vectors are entered in the appropriate columns of a matrix. As a result, a super matrix is actually a partitioned matrix, where each matrix segment represents a relationship between two clusters in a system. The local priority vectors obtained in Step 2 are grouped and placed in the appropriate positions in a super matrix based on the flow of influence from one cluster to another, or from a cluster to itself, as in the loop. A standard form for a super matrix is as shown below.

$$w_{ij} = \begin{bmatrix} w_{11} & w_{1k}..... & w_{1n} \\ w_{k2} & w_{kk}..... & w_{kn} \\ & & \\ w_{n1} & w_{nk}..... & w_{nn} \end{bmatrix}$$

Note that any zero value in the super matrix can be replaced by a matrix if there is an interrelationship of the elements within a cluster or between two clusters. Since there usually is interdependence among clusters in a network, the columns of a super matrix may sum to more than one. However, the super matrix must be modified so that each column of the matrix sums to unity. An approach recommended by Saaty, 1996 involves determining the relative importance of the clusters in the super matrix, using the column cluster as the controlling cluster. That is, row clusters with non-zero entries in a given column cluster are compared according to their impact on the cluster of that column cluster. An eigenvector is obtained from the pair wise comparison matrix of the row clusters with respect to the column cluster, which in turn yields an eigenvector for each column cluster. The first entry of the respective eigenvector for each column cluster, is multiplied by all the elements in the first cluster of that column, the second by all the elements in the second cluster of that column and so on. In this way, the cluster in each column of the super matrix is weighted, and the result, known as the weighted super matrix, is

stochastic. Raising a matrix to exponential powers gives the long-term relative influences of the elements on each other. To achieve convergence on the importance weights, the weighted super matrix is raised to the power of 2k + 1,($W = \text{Lim } W^{2k+1}$)where k is an arbitrarily large number; the new matrix is called the limit super matrix[9]. The limit super matrix has the same form as the weighted super matrix, but all the columns of the limit super matrix are the same. The final priorities of all elements in the matrix can be obtained by normalizing each cluster of this super matrix. Additionally, the final priorities can be calculated using matrix operations, especially where the number of elements in the model is relatively few. Matrix operations are used in order to easily convey the steps of the methodology and how the dependencies are worked out.

Step 4: Selection of the best alternatives: If the super matrix formed in Step 3 covers the whole network, the priority weights of the alternatives can be found in the column of alternatives in the normalized super matrix. On the other hand, if a super matrix only comprises clusters that are interrelated; additional calculations must be made to obtain the overall priorities of the alternatives. The alternative with the largest overall priority should be selected, as it is the best alternative as determined by the calculations made using matrix operations.

NUMERICAL ANALYSIS

This section presents an illustration of the proposed mathematical approach summarized in the previous sections. In the following study, our method utilizing the ANP analysis was conducted on policy holders in northern Tehran and the questionnaires were randomly sent to them via their e-mail addresses(source: BMI) and the same done for the experts. In this paper we want to test if there was a difference between the four mentioned alternatives in selecting a liability or property insurance contract from the view point of policy holders synthesized by experts view. The following example is presented for the purpose of illustration of the proposed approach. The data for the five criteria were generated from the view of policy holders (table 3), experts (table 5) and then our final decision matrix (table 7) is a geometric mean of these two tables. Then, ANP was conducted by super decisions software with the data.

The statistical analysis revealed that the mean was 27.19 and t result was 25.21 at p .001 so the data analysis of data showed that they were significant at $p < 0.05$, and there was a difference between the alternatives importance degree in selecting a property-liability insurer.

ANP calculations: This section consists of 2 parts. a: comparison of criteria with all alternatives and b; comparison of alternatives with all criteria. The results of these comparisons are shown in table 5 as the limit super matrix from the view point of policy holders and table 6 as the Limit super matrix from the view point of experts, Table 8 as super matrix from the view point of experts and policy holders and finally table 9 as the limit super matrix from the view point of experts and policy holders

Table3. Generated data of policy holder's questionnaires

criteria / alternatives	c_1	c_2	c_3	c_4	c_5	Total
A_1	4.5	5.75	5.5	5	5.75	26.5
A_2	5.25	5.25	5.5	5.75	6	27.75
A_3	5.75	5.25	5.5	6	6.25	28.75
A_4	6.25	6	5.5	6.25	6.25	30.25

Table 4 . Limit SUPER MATRIX from the view point of policy holders

$$
w3 = \begin{array}{c} C_1 \\ C_2 \\ C_3 \\ C_4 \\ C_5 \\ A_1 \\ A_2 \\ A_3 \\ A_4 \end{array}
\begin{array}{cccccccccc}
 & C_1 & C2 & C3 & C4 & C5 & A1 & A2 & A3 & A4 \\
\left[\begin{array}{c} \\ \\ \\ \\ \\ \\ \\ \\ \\ \end{array}\right.
& \begin{array}{c} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0.236 \\ 0.244 \\ 0.254 \\ 0.266 \end{array}
& \begin{array}{c} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0.236 \\ 0.244 \\ 0.254 \\ 0.266 \end{array}
& \begin{array}{c} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0.236 \\ 0.244 \\ 0.254 \\ 0.266 \end{array}
& \begin{array}{c} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0.236 \\ 0.244 \\ 0.254 \\ .0266 \end{array}
& \begin{array}{c} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0.236 \\ 0.244 \\ 0.254 \\ 0.266 \end{array}
& \begin{array}{c} .190 \\ .197 \\ .199 \\ .202 \\ .209 \\ 0 \\ 0 \\ 0 \\ 0 \end{array}
& \begin{array}{c} .190 \\ .197 \\ .199 \\ .202 \\ .209 \\ 0 \\ 0 \\ 0 \\ 0 \end{array}
& \begin{array}{c} .190 \\ .197 \\ .199 \\ .202 \\ .209 \\ 0 \\ 0 \\ 0 \\ 0 \end{array}
& \begin{array}{c} .190 \\ .197 \\ .199 \\ .202 \\ .209 \\ 0 \\ 0 \\ 0 \\ 0 \end{array}
\left.\begin{array}{c} \\ \\ \\ \\ \\ \\ \\ \\ \\ \end{array}\right]
\end{array}
$$

Table 5. Generated data of expert's questionnaires

criteria / alternatives	c_1	c_2	c_3	c_4	c_5	Total
A_1	4	5	6.5	3.5	5.5	24.5
A_2	4.5	5.5	6	5.5	5	26.5
A_3	4	5.5	4.5	6	5.5	25.5
A_4	6.5	6.5	3.5	6.5	5.5	28.5

Table 6 . Limit SUPER MATRIX from the view point of EXPERTS

	C_1	$C2$	$C3$	$C4$	$C5$	$A1$	$A2$	$A3$	$A4$
C_1	0	0	0	0	0	.182	.182	.182	.182
C_2	0	0	0	0	0	.209	.209	.209	.209
C_3	0	0	0	0	0	.194	.194	.194	.194
C_4	0	0	0	0	0	.207	.207	.207	.207
$w3 = C_5$	0	0	0	0	0	.208	.208	.208	.208
A_1	0.232	0.232	0.232	0.232	0.232	0	0	0	0
A_2	0.251	0.251	0.251	0.251	0.251	0	0	0	0
A_3	0.244	0.244	0.244	0.244	0.244	0	0	0	0
A_4	0.273	0.273	0.273	.0273	0.273	0	0	0	0

Table 7 Generated data of policy holders & expert's questionnaires, final decision making matrix

criteria alternatives	c_1	c_2	c_3	c_4	c_5	Total
A_1	4.24	5.36	5.98	4.18	5.62	25.38
A_2	4.86	5.37	5.74	5.62	5.47	27.06
A_3	4.79	5.37	4.97	6	5.86	26.99
A_4	6.37	6.24	4.39	6.37	5.86	29.23

Table 8 SUPER MATRIX from the view point of experts and policy holders

	C_1	C_2	C_3	$C4$	$C5$	$A1$	A_2	$A3$	A_4
C_1	0	0	0	0	0	0.17	0.18	0.18	0.22
C_2	0	0	0	0	0	0.21	0.20	0.20	0.21
C_3	0	0	0	0	0	0.24	0.21	0.18	0.15
C_4	0	0	0	0	0	0.16	0.21	0.22	0.22
C_5	0	0	0	0	0	0.22	0.20	0.22	0.20
A_1	0.210	0.24	0.28	.1875	0.25	0	0	0	0
A_2	0.240	0.24	0.27	.2475	0.24	0	0	0	0
A_3	0.240	0.24	0.24	.265	.255	0	0	0	0
A_4	0.310	0.28	0.21	0.30	.255	0	0	0	0

Table 9 Limit SUPER MATRIX from the view point of EXPERTS and policy holders

	C_1	$C2$	$C3$	$C4$	$C5$	$A1$	$A2$	$A3$	$A4$
C_1	0	0	0	0	0	.188	.188	.188	.188
C_2	0	0	0	0	0	.205	.205	.205	.205
C_3	0	0	0	0	0	.194	.194	.194	.194
C_4	0	0	0	0	0	.204	.204	.204	.204
$w3 = C_5$	0	0	0	0	0	.209	.209	.209	.208
A_1	0.233	0.233	0.233	0.233	0.233	0	0	0	0
A_2	0.247	0.247	0.247	0.247	0.247	0	0	0	0
A_3	0.249	0.249	0.249	0.249	0.249	0	0	0	0
A_4	0.271	0.271	0.271	.0271	0.271	0	0	0	0

RESULTS

Strategic analysis provides guidelines for determining objectives for individual business units. In evaluating an insurance company, management must decide whether to: strengthen its position, attempt to shift it into a more desirable position or exit from a particular business unit. Management must develop a strategic plan for each type of insurance contract, taking into account its strategic situation, available resources, forecasts of future competitive and market conditions, and relative attractiveness of available opportunities by a mathematical analysis. The aim of this research was to measure the importance degree of selecting factors of liability-property insurer from the synthesized view of policy holders and experts in order to help decision makers in planning and allocating resources. The participants included policy holders who were randomly selected by cluster sampling method and the instrument was self-administered and reliability of the instrument was measured by Cronbach's alpha (85%). Data analysis was conducted and revealed that mean was 27.19 and t result was 25.21 at p .001 and they were significant at $p < 0.05$, the inconsistency of all matrices was acceptable (rounded about .00185) and below 10% and there was a difference between importance degree of alternatives in selecting a property-liability insurer from their points of view. Results from the limit super matrix (table 9) showed that alternatives prioritization was in this order: 1- quality and quantity of service offered 2- financial stability of insurer 3- cost of coverage 4- availability of coverage ($A_4 > A_3 > A_2 > A_1$).

CONCLUSION

Since not all companies writing insurance are alike in such matters as price of the product, financial strength, quality and quantity of offered service and availability of coverage the buyer when deciding to purchase a property or a liability insurance contract should make an analysis of

the particular insurer before entrusting it with his/her financial security the first step in the intelligent selection is to make sure that each insurer to be analyzed offers a comparable insurance contract and the factors of the cost, financial stability and strength and quality and quantity of services are all interrelated so the final selection of the insurer should be withheld until all factors have been analyzed. In 2011 Yucenur et al. proposed a model for selecting of the global supplier by (AHP) and (ANP) based on linguistic variable weight then fuzzy AHP and fuzzy ANP results were compared [17]. Yazgan in 2011 developed an analytical network process model based on benefit, opportunity, cost, and risk in order to eradicate the weaknesses of traditional methods of Selection of a best dispatching rule based on one or two criteria such as processing time, due date, or manufacturing system information in traditional methods such as mathematical programming, simulation ,and heuristic algorithms weakness such as dispatching rules do not allow the use of multiple criteria for evaluating process, second one is related with not considering most of the manufacturing system information, and the last one deals with selection decision not being a dynamic structure [18]. In 2013 Najafi utilized ANP model to select strategies which would influence the productivity of female workers in strategic decision making level [19].

The ANP is a relatively new MCDM method which can deal with many interactions systematically, unlike traditional MCDM methods which are based on the independence assumption. the ANP can be used not only as a way to handle the inner dependences within a set of criteria, but also as a way of producing more valuable information for decision-making this paper proposes a solution based on a combined ANP and the major property-liability contracts in a management assessment system This approach helps the decision-making team to have a proper solution in management. The results of this study showed that there was a difference between importance degree of alternatives in selecting a property-liability insurer from the perception of policy holders and insurance experts. So in order not to lose market shares each insurance company should pay attention to the importance degree of each alternative unfortunately the Persian insurance practitioners now days mostly take the cost of coverage in to account without consideration to the other alternatives.

ACKNOWLEDGEMENTS

REFERENCES

1. Greene, R. MARK; 1977, RISK AND INSURANCE; SOUTH-WESTERN; 4TH EDITION
2. Whitaker, R., (2007), Validation examples of the Analytic Hierarchy Process and Analytic Network Process, Mathematical and Computer modeling. 46, 840–859.
3. Saaty, T.L., Khouja, M.W., (1976), A measure of world influence, Journal of Peace Science (spring)
4. Saaty. T.L, (1980), The Analytic Hierarchy Process, McGraw-Hill, New York.
5. BMI annual report, Rate of insurance industry in IRI GNP, Journal of economics, (2013), 2324(12) (in Persian)
6. Parente .R, Byeongyong P.C, Arjen H.L, SlangenS.K, (2010), Distribution system choice in a service industry: An analysis of international insurance firms operating in the United State, Journal of International Management 16 275–287.
7. Chung S.H., Lee A.H.L., Pearn W.L.,(2005) Analytic network process (ANP) approach for product mix planning in semiconductor fabricator, International Journal of Production Economics 96 15–36.
8. Figueira J. Salvatore G, Matthias E, (2005), multiple criteria decision analysis, Springer
9. Saaty, T. L. (1996).The analytic network process-decision making with dependence and feedback. Pittsburgh, PA: RWS.
10. Buckley, J. J. (1985).Fuzzy hierarchical analysis. Fuzzy Sets and Systems, 17, 233–247
11. Meade, L. M., & Sarkis, J. (1998). Strategic analysis of logistics and supply chain management systems using the analytic network process. Logistics and Transportation Review, 34(2), 201–215.
12. Sekitani, K., & Takahashi, I. (2001).A unified model and analysis for AHP and ANP. Journal of the Operations, Research Society of Japan, 44(1), 67–89.
13. Tseng, M. L., Lin, Y. H., Chiu, A. S. F., & Liao. H. (2008). Using FANP approach on selection of competitive priorities based on cleaner production implementation: A case study in PCB manufacturer, Taiwan. Clean Technology and Environmental Policy, 10(1), 17–29.
14. Sarkis, J.(1999). A methodological framework for evaluating environmentally conscious manufacturing programs. Computers & Industrial Engineering, 36(4), 793–810.
15. Lapin L. (1990) probability and statistics for modern engineering, PWS-KENT publishing co. BOSTON.
16. Meade L.M., Sarkis J., (1999) Analyzing organizational project alternatives for agile manufacturing processes: an analytical network approach, International Journal of Production Research 37 241–261.
17. Yucenur .G.N. & Vayvay. O. & Demirel N. Ç, (2011), Supplier selection problem in global supply chains by AHP and ANP approaches under fuzzy environment, Int. J Adv Manuf. Technol. 56:823–833

18. Yazgan H.R,(2011), Selection of dispatching rules with fuzzy ANP approach, Int. J Adv Manuf. Technol. 52:651–667

19. Najafi.A.(2013), Analytic network process (ANP) approach for selecting strategies influencing the productivity of knowledge women workers, African Journal of Business Management Vol.7(40) , pp. 4168-4179

LINEAR CONDITIONAL HETEROSCEDASTICITY MODELS, AND A NEW MODEL: CASE STUDY ETF RETURNS OF EMERGING ASIAN COUNTRIES

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ABSTRACT

In this paper, we investigate the long memory returns for ETF returns index of seven Asian countries in Emerging Markets Equities (ETFs) during 2008-2013 periods. Those ETFs are Wisdom Tree Indian Rupee Fund (ICN), Market Vectors Indonesia Index (IDX), iShares MSCI Malaysia Index Fund (EWM), Market Vectors Russia ETF (RSX), and iShares MSCI Thailand Investable Market Index Fund (THD), SPDR S&P China ETF (GXC), and Market Vectors Vietnam ETF (VNM). The EGARCH, ARFIMA, ARFIMA-FIGARCH, and ARFIMA-HYGARCH models were estimated. The empirical results of AIC and log likelihood information criterion analyses, the statistics supports EGARCH and ARFIMA-HYGARCH models instead of ARFIMA and ARFIMA-FIGARCH models.

Keywords: Emerging markets, currency ETF, EGARCH, ARFIMA, ARFIMA-FIGARCH, ARFIMA-HYGARCH

INTRODUCTION

Emerging markets have been marked by several articles of volatility spillovers and contagion (Bodart and Candelon, 2009; Beirne et al., 2010; Brana and Lahet, 2010). Follow history timeline to review some events that affect to financial market, especially emerging markets that were noted in many scholar research papers recent years, those events are,

namely Mexican Peso crisis during 1994-1995 (Truman, 1996; Whitt, Jr., 1996; Griffith-Jones, 1997; Kanas, 2005; Feridun, 2007; Walid, Chaker, Masood, and Fry, 2011), the Asian currency and financial crisis (Radelet and Sachs, 1998; Corsetti, Pesenti, and Roubini, 1999; Wong, 1999; Kim, Kose, Plummer, 2000) and the devaluation of Thailand's bath in 1997 (Kaminsky, Lizondo, and Reinhart, 1999), the Russian financial crisis and the collapse of Long-Term Capital Management (LTCM) in 1998 (Feridun, 2004; Forbes, 2004; Saleem, 2009), the market reaction after the terrorist incident on September 11 in 2001 (Johnston and Nedelescu, 2005; Karolyi and Martell, 2010; Suleman, 2012), the Argentine defaulted debt crisis during 1999–2002 (De la Torre, Yeyati, and Schmukler, 2002; Schuler, 2005; Kehoe and Prescott, 2007); the U.S. high-yield market sell-off in 2002 (Altman and Bana, 2003; Reilly, Wright, and Gentry, 2009); the U.S. 2007 Subprime Crisis (Frank, González-Hermosillo, and Hesse, 2008; Dooley and Hutchison, 2009;), and the global financial crisis of 2007–2009 (Bunda et al., 2009; Frank and Hesse, 2009; Guillén and Suárez, 2009; Melvin and Taylor, 2009; Bunda, Hamann, and Lall, 2010; Rocha and Moreira, 2010; Merrouche and Nier, 2010; Swedberg, 2010; Atkinson, Luttrell and Rosenblum, 2013). Kanas (2005) and Walid et al. (2011) proved evidence of regime dependence between the Mexican currency market and the volatility of some Asian emerging markets. The ruble's massive devaluation followed by sovereign debt default boosted emerging market risk and suppressed commodity exports from emerging markets to Russia (Saleem, 2009). Following Mexico's December 1994 peso devaluation, capital flows out of emerging markets. Foreign banks and other institutional investors from Europe and later the United States, all flush with funds, soon discovered Asia's emerging markets, where interest rates were high and risk was very low because currencies were pegged to the U.S. dollar (Wong, 1999). Stock returns of the Asian countries then moved again to the high volatility regime in October 1997 corresponding to the Asian currency crisis (Tai, 2007; Walid, Chaker, Masood, and Fry, 2011). The events Russian crisis of 1998, the Brazilian crisis of 1999, and stock market volatility increased in late 2001 as a result of the 9/11 terrorist attack affects all the Asian stock markets and a spell of high volatility (Walid, Chaker, Masood, and Fry, 2011). Besides, the Asian markets switch to a regime of high volatility in mid 2007 may be attributed to the subprime crisis in the U.S. (Walid, Chaker, Masood, and Fry, 2011). Besides, capital flows to emerging markets increased dramatically due mainly to the structural changes and economic liberalization in the 1990s (Bekaert et al., 1997; Bekaert and Harvey, 2000). Therefore, emerging markets offered high rates of returns, high volatility, high risk in comparison to developed markets as well as low correlation with developed markets during the first half of the 1990s (Harvey, 1995; Bekaert et al., 1997; Bekaert and Harvey, 2000). However, the performance characteristics of emerging markets changed over the last half of the 1990s because of financial crises as well as the financial and economic integration of emerging

markets with the developed markets (Bekaert et al., 1997; Bekaert and Harvey, 2000; Bruner et al., 2003; Li et al., 2003; M. Kortas et al., 2005; Fan et al., 2011). Further, there are many researchers studied about firms in emerging markets (Klapper and Love, 2004; Aggarwal, Dahiya, and Klapper, 2007; Bleakley and Cowan, 2010; Pinegar, Ravichandran, 2010; Fan et al., 2011; Liu, 2011), the diversification benefits of investing in emerging markets (Kargin, 2002; Bruner, Conroy, Li, O'Halloran, Lleras, 2003; Li et al., 2003; Guest editorial, 2006; Jung et al., 2009; Naranjo and Porter, 2007; Walid et al., 2011), and interest-rate volatility in emerging markets (Hamilton and Susmel, 1994; Edwards and Susmel, 2003) making these topics popular recent years. The previous researchers studied about the emerging markets in specific regions such as Europe, Latin America (Chang et al., 2004), Middle East and North Asia - MENA (Lagoarde-Segot and Lucey, 2008; Jahan-Parvar and Waters, 2009), and Asia (Bekaert and Harvey, 1995; De Santis and Imrohoroglu, 1997; Nakagawa, 2007; Tai, 2007) or all emerging market countries in general (Canela, Collazo, 2007; Naranjo and Porter, 2007; Aggarwal and Goodell, 2009; Beirne, Caporale, Schulze-Ghattas and Spagnolo, 2009). The Asian emerging markets have greater predilection towards markets (Nakagawa, 2007; Aggarwal and Goodell, 2009).

The earlier researchers realized that there are not many studies which have specifically investigated the performances of ETFs that purposely dig into global emerging markets equity indexes (Blitz and Huij, 2012). However, there are several papers for emerging equity markets and the impact of FX rate changes on stock market volatility of emerging markets (Bekaerta and Harvey, 1997; Kanas, 2005; Kortas, L'Her, Roberge, 2005; Canela and Collazo, 2007; Aloui and Jammazi, 2008; Wang and Theobald, 2008; Donadelli and Prosper, 2011; Walid et al., 2011). Global emerging markets are countries such as South Korea, China, India, Brazil, South Africa and Russia, which have become increasingly important to investors due to their fast growing economies (Klapper et al., 2004; Blitz and Huij, 2012). Besides, stocks in emerging markets are less liquid and have higher trading costs than stocks in developed markets (Domowitz et al., 2001; Bekaert et al., 2002; Chiyachantana et al., 2004; Blitz and Huij, 2012). The return in emerging markets is structurally higher than in the U.S., Europe and the Japan-Pacific regions (Harvey, 1995; Dey 2005; Phylaktis and Xia, 2006; Berrill and Kearney, 2011; Blitz and Huij, 2012). The diversification benefits are larger in emerging than developed markets (Li et al., 2003; Jung et al., 2009; Naranjo and Porter, 2007; Walid et al., 2011). At another side, long memory is more often found in emerging market stock returns than in developed markets (Barkoulas et al., 2000; Wright, 2001; Sourial, 2002; Limam, 2003; Assaf, 2006; Floros et al., 2007; Kang and Yoon, 2007). Since stock markets in emerging countries have become an important source for global portfolio diversification, understanding of the dynamic behavior of stock returns in these countries is crucial for portfolio managers,

policy makers, and researchers (Kasman et al., 2009).

The world's emerging markets have become the focus of sustained research in the past two decades. Emerging markets comprise the majority of the world's people and land, and they continue to grow faster than the developed world. They are increasingly recognized as a diverse set of business, cultural, economic, financial, institutional, legal, political and social environments within which to test, reassess and renew received wisdoms about how the business world works, to gain deeper insights into prevailing theories and their supporting evidence, and to make new discoveries that will enhance human welfare in all environments including the world's poorest countries, the developing world, the transition countries and the developed world. The world is dominated by emerging economies in terms of population and geographic size. Emerging countries make up about three quarters of the world's land mass and emerging markets are diverse in culture, language and politics (Kearney, 2012). The emerging markets in Asia include China, India, Indonesia, Israel, Jordan, Malaysia, Pakistan, the Philippines, South Korea, Taiwan, Thailand, Turkey and the UAE (Bleakley and Cowan, 2010; Kearney, 2012). Within those Asia emerging countries, Philippines, Taiwan, Indonesia and South Korea with volatilities higher than 30% (Bekaert and Harvey, 1997). In the past two decades, emerging markets have grown swiftly, with the rise of several largest economies such as Russia, China and India (Kraeussl and Logher, 2010; Rocha and Moreira, 2010; Fan, Wei, and Xu, 2011). The two largest Asian emerging countries, China and India, are expected to lead this growth. Thailand is another large emerging market that is well-known to international investors (Bekaert and Harvey, 1997). In addition, emerging market (EM) research is a fascinating multidisciplinary area that incorporates disciplines as disparate as anthropology, genetics, geography, history, philosophy, psychology, physics and sociology in addition to the standard business disciplines of economics, finance, international business and management (Kearney, 2012). Researchers dig in emerging markets more and more. Notable examples include Fifield et al. (1999) who examined the criteria defining emerging markets and summarized the previous two decades' work, focusing mostly on equity markets. Bekaert and Harvey (1997, 2003) reviewed research on finance in emerging markets, focusing mainly on 20 countries with the longest available spans of data on the International Finance Corporation's (IFC) emerging market database. Other researchers have provided surveys of topics in EM research. Khilji (2003) reviewed financial crises; Phylaktis (2006) focused on asset management, contagion, corporate finance and market integration; and Lien and Zhang (2008) surveyed derivative markets. More recently, Fan et al. (2011) provided an authoritative overview of how key institutional forces in emerging markets such as government quality, the extent of state ownership, and the degree of financial development, impact upon the structures and behaviors of firms including their investments, financing,

governance and growth. They suggested areas for new EM research including government incentives, informal enforcement procedures, family firms and network organizations.

Malaysia and Russia are the most power distance emerging countries (Elenkov, 1998; Ionascu, Meyer, & Erstin, 2004; Ghemawat & Reiche, 2011; Borker, 2012). Russia is the most uncertainty-avoidance emerging markets (Voros & Choudrie, 2011; Rapp, Bernardi & Bosco; 2011; Filippov, 2012). India and the Philippines are most comfortable with uncertainty and ambiguity emerging markets (Lang & Maffett, 2011; Brandao-Marques, Gelos, & Melgar, 2013). The potential return of emerging markets remains higher in comparison to those of developed market counterparts (Kortas, L'Her, Roberge, 2005). Bruner et al. (2003) noted that at the end of December 2002, emerging markets represent 10.5% of the world market capitalization while they account for 20% of the world GDP. Due to many facts of advantages in Asia emerging markets, more attention has been paid by not only international scholars but also international investors. Therefore, the scholars studied Asian emerging equity or FX markets and Asian emerging stock markets more and more year by year (Brunetti et al., 2008; Flavin et al., 2008; Wang and Theobald, 2008; Bodart and Candelon, 2009; Beirne et al., 2010; Bleakley and Cowan, 2010; Brana and Lahet, 2010; Walid et al., 2011). The sample consists of some Asia countries emerging markets, namely Indonesia, Malaysia, Philippines, South Korea, and Thailand from year 2008 to year 2013. Since emerging markets are less integrated than developed markets, the diversification benefits available from including them in international momentum investing strategies should be large. Naranjo and Porter (2007) examined the diversification benefits from including emerging markets in an international momentum investment strategy.

Section 2 of the paper reviews some literatures of ARCH models and ARFIMA models, namely ARIMA, ARFIMA, EGARCH, FIGARCH, HYGARCH, ARFIMA-FIGARCH, and ARFIMA-HYGARCH. Section 3 discusses about methodology and data analysis. Section 4 reports some applications and empirical results of EGARCH, ARFIMA, ARFIMA-FIGARCH, and ARFIMA-HYGARCH. The four models are applied to seven currency ETFs series in Asian emerging markets covering the 2008-2013 periods. Section 5 concludes the paper.

LITERATURE REVIEWS

EGARCH (Nelson, 1991) and FIGARCH (Baillie et al., 1996, Ding & Granger, 1996) are variants of ARCH model's conditional volatility which have been proposed by Engle in 1982. All of these models, and many other cases that might be devised, fall into the class in

which the conditional variance at time t is an infinite moving average of the squared realizations of the series up to time t − 1.

ARIMA model

ARMA(p,q) models are discussed as combinations of the AR and MA models. These are called autoregressive moving an average (ARMA) model, which is defined as:

$$\Phi(L)y_t = \theta(L)\varepsilon_t$$

Where ε_t is purely random process with mean zero and variance σ^2. It can be rewritten using the lag operator L as:

$$\Phi(L) = (1 - \alpha_1 L - \alpha_2 L^2 - \ldots - \alpha_p L^p)$$

Where $\Phi(L)$ and $\theta(L)$ are polynomials of orders p and q, respectively, defined as

$$y_t = \alpha_1 y_{t-1} + \varepsilon_t + \theta_1 \varepsilon_{t-1}$$

For example, the ARMA(1,1) process is:

$$y_t = \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + \alpha_p y_{t-p} + \varepsilon_t + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \ldots + \theta_q \varepsilon_{t-q}$$

In terms of the lag operator L this can be written as:

$$(1 - \alpha_1 L)y_t = (1 + \theta_1 L)\varepsilon_t \text{ or } y_t - \alpha_1 y_{t-1} = \varepsilon_t + \theta_1 \varepsilon_{t-1}$$

$$y_t = [(1 + \theta_1 L)/(1 - \alpha_1 L)]\varepsilon_t$$

Since ε_t is a pure random process with variance σ^2 we get

$$Var(y_t, y_{t-1}) = \{[(\alpha + \theta)(1 + \alpha\theta)]/(1 - \alpha^2)\} \sigma^2 \text{ hence}$$

$$\rho(1) = cov(y_t, y_{t-1})/var(y_t) = [(\alpha + \theta)(1 + \alpha\theta)]/(1 + \theta^2 + 2\alpha\theta)$$

Successive values of $\rho(k)$ can be obtained from the recurrence relation $\rho(k) = \alpha\rho(i-1)$ for $k \geqq 2$. Thus, the ACF for an ARMA(1,1) process is such that the magnitude of ρ_1 depends on both *a* and ɵ.

In the operator $\Delta = 1-L$ so that $\Delta y_t = y_t - y_{t-1}$, $\Delta^2 y_t = (y_t - y_{t-1})-(y_{t-1} - y_{t-2})$, and so on, $\Delta^d y_t$ is supposed a stationary series that can be represented by an ARMA(p,q) model. Then, y_t can be represented by an autoregressive integrated moving average model, ARIMA(p,d,q). The model is called an integrated model because the stationary ARMA model that is fitted to the differenced data has to be summed or "integrated" to provide a model for the nonstationary data.

ARFIMA (Autoregressive fractionally integrated moving average):

Granger and Joyeux (1980) and Hosking (1981) proposed an ARFIMA model which is: $\Phi(L)(1-L)^d (X_t - \mu)=\theta(L)\varepsilon_t$ and proposed the method to fit long-memory data. ARFIMA(p,d,q) is written as follow: $\varphi(L)\Delta^d y_t = \delta + \theta(L)u_t$ with $\varphi(L) = (1 - \varphi_1 L - \ldots - L^p)$ and $\theta(L) = (1 - \theta_1 L - \ldots - \theta_q L^q)$ where: $\delta =$ a constant term; $\theta(L) =$ the MA operator at order q; $u_t =$ an error term; $\varphi(L) =$ the AR operator at order p; $\Delta^d y_t =$ the differencing operator at order d of time series data y_t. ARFIMA (Autoregressive fractionally integrated moving average) model is time series model that generalized ARIMA (autoregressive integrated moving average) model by allowing non-integer values of the differencing parameter. These models are useful in modeling time series with long memory - that is, in which deviations from the long-run mean decay more slowly than an exponential decay. A general multiplicative seasonal ARIMA model for time series Z_t is as follows:

$$\varphi(L)\Phi(L^s)(1-L)^d(1-L^s)^D Z_t = \theta(L)\rho(L^s)\alpha_t \text{ where:}$$

$L =$ a backshift or lag operator $(B_{zt} - Z_{t-1})$;
$S =$ seasonal period;
$\varphi(L) = (1 - \varphi_1 L - \ldots - L^p)$ is the non-seasonal AR operator;
$\Phi(L^s) = (1 - \Phi_1 L^s - \ldots - \Phi_s L^s)$ is the seasonal AR operator;
$\theta(L) = (1 - \theta_1 L - \ldots - \theta_q L^q)$ is the non-seasonal MA operator;
$\rho(L) = (1 - \rho_1 L^s - \ldots - \theta_0 L^{Qs})$ is the seasonal MA operator;
$(1 - L)^d(1 - L^s) =$ non-seasonal differencing of order d and seasonal differencing of order D.

The process is called stationary when the ARFIMA model is $-0.5<d<0.5$. This is where the effect of shocks to ε_t decays at a gradual rate to zero. Also, the process has a short memory if $d=0$. This is where the effect of shock decays geometrically. A unit root process is exhibited when $d=1$. A long memory process or the so-called positive dependence among remote observations exists when $0<d<0.5$. On the other hand, there is a presence of

intermediate memory or anti-persistence when -0.5<d<0 (Baillie, 1996). The process is non-stationary if d$\geqq$0.5 (Galbraith & Zinde-Walsh, 2001). While it is stationary but noninvertible process if d$\leqq$-0.5, making the time series impossible to model by any autoregressive process.

EGARCH model

EGARCH is short for Exponential Generalized Auto Regressive Conditional Heteroskedasticity. The GARCH process is a popular stochastic process which has been fairly successful in modeling financial time series (Engle, 2004). The exponential GARCH (EGARCH) model is where the logarithm of the conditional variance is modeled (Nelson, 1991). EGARCH models are which describes the dynamics of log volatility (of which the log range is a linear proxy) (Nelson, 1989, 1990, 1991, Pagan & Schwert, 1990; Hentschel, 1995). EGARCH models can accommodate asymmetric volatility (often called the "leverage effect"), where increases in volatility are associated more often with large negative returns than with equally large positive returns. EGARCH models provide forecasts of future log volatility (or log variance). Since periods of currency ETFs seem to be clustered in time, an asymmetrical EGARCH model (Nelson, 1991) is therefore estimated to accommodate for volatility clustering and for asymmetry in the volatility process. Noting that, an EGARCH model can be represented as an ARMA process in terms of the logarithm of conditional variance and thus always guarantees that the conditional variance is positive. Nelson (1991) proposed the following exponential GARCH (EGARCH) model to allow for leverage effects:

$$\sum_{i=1}^{p} \alpha_i \; \frac{|\varepsilon_{t-i}| + \gamma_i \varepsilon_{t-i}}{\sigma_{t-i}} \; + \; \sum_{j=1}^{q} \beta_j h_{t-j}$$

FIGARCH model: Fractional integrated general autoregressive conditional heteroskedasticity model

The FIGARCH model of Baillie et al. (1996): $\sigma^2_t = \{1-[1 - \beta(L)]^{-1} (1-L)^d \Phi(L)\} \varepsilon^2_t$

Fractionally Intergrated Garch (FIGARCH) model is proposed to determine long memory in return volatility. Baillie et al. (1996) have extended the traditional GARCH model to capture the long memory component in the return's volatility. The FIGARCH(p,d,q) process is as follow:

$[\Phi(L)(1 - L)^d]\varepsilon^2_t = \omega + [1 - \beta(L)](\varepsilon^2_{t-} \sigma^2_t)$ where $v_t = u^2_t - \sigma^2_{t,t}$ 0<d<1, $\Phi(L) = \sum_{i=1}^{n-1} \varphi_i L^i$ is of order m-1, and all the roots of $\Phi(L)$ and $[1 - \beta(L)]$ lie outside the unit circle.

The FIGARCH model is derived from standard GARCH model with fractional different operator $(1-L)^d$. The FIGARCH(p,d,q) model is reduced to the standard GARCH when d=0 and becomes IGARCH model when d=1. It is well known that for $0<d\leq1$ the FIGARCH(p,d,q) process has an undefined unconditional variance. However, the process does possess cumulative impulse response weights with a finite sum. This property makes the FIGARCH model different from other possible forms of long memory ARCH models. Further, in terms of hyperbolic memory, an alternative definition for the persistence properties of the FIGARCH process makes more precise the distinction of the FIGARCH model from the shorter (geometric) memory cases represented by the GARCH and IGARCH processes (Davidson, 2004).

HYGARCH Model

The HYGARCH model was introduced as a generalization of FIGARCH with hyperbolic convergence rates (Davidson, 2004). These models fall in the class of models where the conditional variance at time t is an infinite moving average of the squared realizations of the series up to time $t-1$. The proposed HYGARCH model permits both the existence of second moments and more flexibilities than the IGARCH and FIGARCH models (Kwana, Lib, & Li, 2012). Consider, for comparability with the previous cases, the form:

$$\Theta(L) = 1 - \frac{\delta(L)}{\beta(L)} (1 + \alpha((1-L)^d - 1)) \quad \alpha \geq 0, d \geq 0.$$ Note that provided $d > 0$, $S = 1 - \frac{\delta(1)}{\beta(1)} (1 - \alpha)$.

It is known that a GARCH (p,q) model can be rewritten as an ARMA model in squares:

$$\Phi(L)\epsilon_t^2 = \alpha_0 + \beta(L)v_t, \text{ where } v_t = \epsilon_t^2 - h_t \text{ or the term can be rewritten as:}$$

$$h_t = (\alpha_0 / \beta(1)) + (1 - \frac{\varphi(L)}{\beta(L)}) \epsilon_t^2 = \alpha_0 + \lambda(L)\epsilon_t^2$$

Davidson (2004) shows that the HYGARCH is capable of modeling the volatility dynamics in three Asian currencies during the crisis period 1997-1998. Niguez and Rubia (2006) apply the HYGARCH model to a portfolio of five exchange rates and report that it clearly outperforms simpler GARCH variants in terms of out-of-sample forecasting. Tang and Shieh (2006) compare the performance of FIGARCH and HYGARCH models in predicting Value-at-Risk for three stock index futures markets.

The ARFIMA-FIGARCH

In several studies discussions, the ARFIMA-FIGARCH model was applied to show significant evidences of long memory model in Japanese equity (Nagayasu, 2003), in financial stock exchange (Cheong, 2007), in Istanbul stock exchange (Korkmaz et al 2009), in Turkish stock market (Kasman & Torun, 2007), and in future markets in Turkey (Yalama et al., 2011). Besides, ARFIMA-FIGARCH model also showed a presence of dual long memory model in Daily Exchange Rates (Beine et al., 2002), in Korean stock market (Kang & Yoon, 2012). In addition, the ARFIMA-FIGARCH model suggested long memory in the conditional mean and variance of financial processes (Conrad & Karanasos, 2005; Fiszeder, 2006). Further, the ARFIMA-FIGARCH model was applied to test the efficiency of Japanese equity market (Nagayasu, 2003), to predict stock returns (Sivakumar & Mohandas, 2009). Moreover, ARFIMA-FIGARCH model was also used for forecasting (Chokethaworn et al, 2010).

ARFIMA-FIGARCH model is an association between ARFIMA model and FIGRACH model (Kang & Yoon, 2012). In the other words, the ARFIMA-FIGARCH model is an association of appropriate lags ARFIMA (n,s)-FIGARCH(p,q) (Sandu, 2009).

The ARFIMA-HYGARCH

The ARFIMA-HYGARCH model is a long-memory model for the conditional mean and the conditional variance as well (Kwan et al., 2012). An ARFIMA(1,d,0)-HYGARCH(1,d_{FG},1) model was applied to ten daily exchange rates series and also to some Asian exchange rates over the 1997 crisis period (Davidson, 2004). Davidson (2004) used the Student's t distribution to fit the GARCH models in order to estimate the ARFIMA–HYGARCH models. The method was proposed by Bollerslev (1987).

Let $\{y_t\}$ be a stationary and ergodic time series generated by the ARFIMA(p,d_{ARF},q) process,

$(1 - L)^{d_{ARF}} \varphi(L)y_t = \psi(L)e_t$, (1)

in which the error sequence $\{e_t\}$ follows the HYGARCH(r,d_{FG},s) model,

$e_t = \varepsilon_t h_t^{1/2}$, $h_t = \gamma + \{1 - [1 - \alpha + \alpha(1 - L)^{d_{FG}}]\frac{\varphi(L)}{\beta(L)}\}e_t^2$, (2)

where L is the back-shift operator, $\varphi(x) = 1 - \sum_{k=1}^{p} \varphi_k x^k$, $\psi(x) = 1 - \sum_{k=1}^{q} \psi_k x^k$, $\delta(x) = 1 - \sum_{k=1}^{r} \delta_k x^k$, $\beta(x) = 1 - \sum_{k=1}^{s} \beta_k x^k$, and p, q, r and s are known positive integers; also take the innovation sequence $\{\varepsilon_t\}$ to be identically and independently distributed (i.i.d.) with mean zero and variance one, and

$(1 - L)^d = 1 - \sum_{j=1}^{\infty} \frac{d\Gamma(j-d)}{\Gamma(1-d)\Gamma(j+1)} L^j$ as $0<d<1$.

Denoting $\theta_V = (\gamma, \beta_1, \ldots, \beta_s, \delta_1, \ldots, \delta_r, d_{FG}, \alpha)'$, model (2) can be rewritten into the following ARCH(∞) form:

$$h_t = \gamma + \pi(L)e_t^2 = \gamma + \sum_{j=1}^{\infty} \pi_j e_{t-j}^2 \quad (3)$$

where the π_j's are functions of θ_V. Let $\theta_M = (\varphi_1, \ldots, \varphi_p, \psi_1, \ldots, \psi_q, d_{ARF})'$. Then $\theta = (\theta'_M, \theta'_V)'$ is the parameter vector of models (1) and (2), called the ARFIMA(p,d_{ARF},q)–HYGARCH(r,d_{FG},s).
The parameters $\alpha \geq 0$, $0 < d_{FG} \leq 1$ and $\sum_{j=1}^{\infty} \pi_j < 1$; the polynomials $\delta(x)$ and $\beta(x)$ have no common root and all the roots of these two polynomials are outside the unit circle.

When $d_{FG} = 0$, the conditional variance model becomes an ordinary GARCH model. Thus, the focus of this article will be on the range $0 < d_{FG} \leq 1$. There are two kinds of memory to be recognized: hyperbolic decaying memory and geometric decaying memory, with the former being defined as long memory (Davidson, 2004). For model (2), when $0 < d_{FG} < 1$, $\pi_j = O(j^{-1-d})$, i.e. the coefficients decay hyperbolically, and the conditional variance h_t in (3) or (2) will exhibit the long-memory effect. The condition $\sum_{j=1}^{\infty} \pi_j < 1$ is necessary and sufficient for the ARCH(∞) process (3) to be strictly stationary with finite second moment (Giraitis et al., 2000; Kokoszka & Leipus, 2000l; Zaffaroni, 2004).

METHODOLOGY AND DATA ANALYSIS

The data are Emerging Markets Equities ETFs that are obtained from yahoo finance and ETF database website at http://etfdb.com/etfdb-category/emerging-markets-equities/. The collected data of seven ETFs are from seven Asian emerging countries, those are Wisdom Tree Indian Rupee Fund (ICN), Market Vectors Indonesia Index (IDX), iShares MSCI Malaysia Index Fund (EWM), Market Vectors Russia ETF (RSX), and iShares MSCI Thailand Investable Market Index Fund (THD), SPDR S&P China ETF (GXC), and Market Vectors Vietnam ETF (VNM) starting from the date April 02, 2008 up to December 31, 2013. That means about 5 years data was used for the further computation. The database information is shown in the table 1 below:

Table 1. Database information				
ETFS	Code	Periods		Obs.
iShares MSCI Malaysia Index Fund (EWM)	EWM	2008-4-02	2013-4-01	1258
SPDR S&P China ETF	GXC	2008-4-02	2013-12-31	1449
Wisdom Tree Indian Rupee Fund (ICN)	ICN	2008-5-23	2013-4-01	1220
Market Vectors Indonesia Index (IDX)	IDX	2009-1-21	2013-4-01	1054
Market Vectors Russia ETF (RSX)	RSX	2008-4-02	2013-4-01	1258
iShares MSCI Thailand Investable Market Index Fund (THD)	THD	2008-4-02	2013-3-08	1243
Market Vectors Vietnam ETF	VNM	2009-8-17	2013-12-31	1102

The time series of EWM has sample size 1258 observations during (April 2, 2008 – April 1, 2013). The time series of GXC has sample size 1449 observations during (April 02, 2008 – December 31, 2013). The time series of ICN has sample size 1220 observations during (May 23, 2008 – April 01, 2013). The time series of IDX has sample size 1054 observations during (January 21, 2009 – April 01, 2013). The time series of RSX has sample size 1258 observations during (April 02, 2008 – April 01, 2013). The time series of THD has sample size 1243 observations during (April 02, 2008 – March 8, 2013). The time series of VNM has sample size 1102 observations during (August 17, 2009 – December 31, 2013).

The average return form of seven ETFs and the standard deviation of these ETFs average returns are showed in the followed table 2.

Table 2. ETFs' mean and standard deviation		
Variable	Mean	Std.dev
EWM	0.007321	0.62862
GXC	0.001823	1.066
ICN	0.000469	0.41486
IDX	0.056281	0.90493
RSX	-0.019551	1.51150
THD	0.019924	0.96032
VNM	-0.012829	0.81617

In the next table (see table 3), the values of Skewness, Excess Kurtosis, and Jarque-Bera probability will be showed.

Table 3. Normality Test		Skewness	Excess Kurtosis	Jarque-Bera
Variable		**Skewness**	**Excess Kurtosis**	**Jarque-Bera**
EWM	**Statistic**	0.050945	3.4851	637.20
	P-Value	(0.4601)	(5.0366e-141)***	(4.3065e-139)***
GXC	**Statistic**	0.30874	8.9619	4872.1
	P-Value	(1.5635e-006)***	(0.00000)***	(0.00000)***
ICN	**Statistic**	0.58990	22.853	26620
	P-Value	(3.7003e-017)***	(0.00000)***	(0.00000)***
IDX	**Statistic**	0.11394	2.8006	346.74
	P-Value	(0.1304)	(3.0155e-077)***	(5.0958e-076)***
RSX	**Statistic**	-0.44896	9.0375	4323.5
	P-Value	(7.5864e-011)***	(0.00000)***	(0.00000)***
THD	**Statistic**	-0.2868	5.1295	1379.7
	P-Value	(3.5785e-005)***	(0.00000)***	(2.4643e-300)***
VNM	**Statistic**	-0.13902	1.0199	51.308
	P-Value	(0.059212)	(4.3178e-012)***	(7.2215e-012)***
Notes: t/z statistics in brackets. * significant at 10%; ** significant at 5%; * significant at 1%.**				

Skewness value of EWM is 0.050945; comes in the form of "positive Skewness". Data points are skewed to the right (positive skew) of the data average. With a skewness of 0.050945 – between +0.5 and +1, the distribution is moderately skewed, the sample data for Malaysian ETF (April 02, 2008 – April 01, 2013) is moderately skewed. Positive excess kurtosis (leptokurtic) = 3.4851 (>0). Compared to a normal distribution, its central peak is higher and sharper, and its tails are longer and fatter. Jarque-Bera's p-value is 4.3065e-139; the series is not normally distributed.

Skewness value of GXC is 0.30874; comes in the form of "positive Skewness". Data points are skewed to the left (positive skew) of the data average. With a skewness of 0.30874 – between +0.5 and +1, the distribution is moderately skewed, the sample data for Chinese ETF (April 02, 2008 – December 31, 2013) is moderately skewed. Positive excess kurtosis (leptokurtic) is 8.9619 (>0). Compared to a normal distribution, its central peak is higher and sharper, and its tails are longer and fatter. Jarque-Bera's p-value is 8.6328e-163; the series is not normally distributed.

Skewness value of ICN is 0.58990; comes in the form of "positive Skewness". Data points are skewed to the right (positive skew) of the data average. With a skewness of 0.58990 – between +0.5 and +1, the distribution is moderately skewed, the distribution is moderately skewed, the sample data for Indian ETF (May 23, 2008 – April 01, 2013) is moderately skewed. Positive excess kurtosis (leptokurtic) is 22.853 (>0). Compared to a normal distribution, its central peak is higher and sharper, and its tails are longer and fatter. Jarque-Bera's p-value is 0.00000; the series is normally distributed.

Skewness value of IDX is 0.11394; comes in the form of "positive Skewness". Data points are skewed to the right (positive skew) of the data average. With a skewness of 0.11394 – between −0.5 and +0.5, the distribution is approximately symmetric, the distribution is moderately skewed, the distribution is moderately skewed, the sample data for Indonesian ETF (January 21, 2009 – April 01, 2013) is moderately skewed. Positive excess kurtosis (leptokurtic) is 2.8006 (>0). Compared to a normal distribution, its central peak is higher and sharper, and its tails are longer and fatter. Jarque-Bera's p-value is 5.0958e-076; the series is not normally distributed.

Skewness value of RSX is -0.44896; comes in the form of "negative Skewness". Data points are skewed to the right (negative skew) of the data average. With a skewness of -0.44896 – between −0.5 and +0.5, the distribution is approximately symmetric, the distribution is moderately skewed, the distribution is moderately skewed, the sample data for Russian ETF (April 02, 2008 – April 01, 2013) is moderately skewed. Positive excess kurtosis (leptokurtic) is 9.0375 (>0). Compared to a normal distribution, its central peak is higher and sharper, and its tails are longer and fatter. Jarque-Bera's p-value is 0.00000; the series is normally distributed.

Skewness value of THD is -0.28681; comes in the form of "negative skewness". Data points are skewed to the left (negative skew) of the data average. With a skewness of -0.28681 – between -0.5 and 0.5, the sample data for Thailand ETF (April 02, 2008 – March 8, 2013) are approximately symmetric. Positive excess kurtosis (leptokurtic) = 5.1295 (>0). Compared to a normal distribution, its central peak is higher and sharper, and its tails are longer and fatter. Jarque-Bera's p-value = 2.4643e-300, the series is not normally distributed.

Skewness value of VNM is -0.13902; comes in the form of "negative skewness". Data points are skewed to the left (negative skew) of the data average. With a skewness of -0.13902 – between -0.5 and 0.5, the sample data for Vietnamese ETF (August 17, 2009 – December 31, 2013) are approximately symmetric. Positive excess kurtosis (leptokurtic) =

1.0199 (>0). Compared to a normal distribution, its central peak is higher and sharper, and its tails are longer and fatter. Jarque-Bera's p-value = 7.2215e-012, the series is not normally distributed.

The result table of ARCH (1-5) test shows that all the probability values of the six ETFs are significant.

Table 4: ARCH effect test				
EWM	ARCH 1-5 test:	F(5,1247) =	49.633 [0.0000]***
GXC	ARCH 1-5 test:	F(5,1438) =	97.786 [0.0000]***
ICN	ARCH 1-5 test:	F(5,1209) =	75.873 [0.0000]***
IDX	ARCH 1-5 test:	F(5,1043) =	20.409 [0.0000]***
RSX	ARCH 1-5 test:	F(5,1247) =	106.99 [0.0000]***
THD	ARCH 1-5 test:	F(5,1232) =	54.993 [0.0000]***
VNM	ARCH 1-5 test:	F(5,1091) =	7.1867 [0.0000]***
Notes: t/z statistics in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%.				

We should significantly reject the null hypothesis of No ARCH Effects. Then, we test if these ETFs data have serial correlation. The results are showed in table 5.

Table 5: Serial correlation test			
Variable	Q-Statistics on Raw data		
EWM	Q(10) =	47.5024	[0.0000008]**
GXC	Q(10) =	58.7431	[0.0000000]**
ICN	Q(10) =	62.5285	[0.0000000]**
IDX	Q(10) =	20.8498	[0.0221654]**
RSX	Q(10) =	17.4598	[0.0647890]
THD	Q(10) =	47.0579	[0.0000009]**
VNM	Q(10) =	8.08224	[0.6208039]
H0 : No serial correlation ➔ Accept H0 when prob. Is High [Q < Chisq(lag)]			
Notes: Q-statistics in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%.			

The Q-statistics tells whether the series has serial correlation. This study selected 10 lags. The number should not be significant and must accept the null hypothesis of No serial correlation. As the results, probability values of VNM and RSX are not significant so the null hypothesis of No serial correlation is accepted for these two ETFs.

ETFs	Period	Obs.	Mean	Std. Dev.	Skewness	Kurtosis	J-Bera	Q(10)
EWM	2008-04-02	1258	0.007321	0.62862	0.05094	3.4851	637.20	47.5024
GXC	2008-4-02	1449	0.001823	0.30874	8.9619	4872.1	97.786	58.7431
ICN	2008-05-23	1220	0.000469	0.41486	0.58990	22.853	26620.	62.5285
IDX	2009-01-21	1054	0.056281	0.90493	0.11394	2.8006	346.74	20.8498
RSX	2008-04-02	1258	-0.01955	1.51150	-0.44896	9.0375	4323.5	17.4598
THD	2008-04-02	1243	0.019924	0.96032	-0.28681	5.1295	1379.7	47.0579
VNM	2009-8-17	1102	-0.012829	0.81617	-0.13902	1.0199	51.308	8.08224

Table 6: The sample size and period of emerging market's ETFs

Normality test for this data: skewness results of RSX, THD, and VNM are negative, it means the skewness slopes of the ETFs move to the left because the values smaller than 0. In the other words, we can say they are not normal curves. in the opposite, skewness results of EWM, GXC, ICN and IDX are positive, it means the skewness slopes of the ETFs move to the right because the values bigger than 0. So they are not normal curves. Kurtosis values of all seven ETFs are positive and they tend to pointed curve because the values are bigger than 0. The results of J.Bera probability values test are all significant. In fact, the data are accepted or the error terms are distributed normally. Q-statistic results of this test are all higher than chi square lag {Q < Chisq(lag)} so the values should not be significant and must accept the null hypothesis of No serial correlation. However, there are only two ETFs RSX and VNM are not significant so the null hypothesis of no serial correlation is accepted for these two ETFs.

ARFIMA and HYGARCH models are used for the analyses and final results.

APPLICATIONS AND EMPIRICAL RESULTS

Table 7 below shows all the slots of six ETFs

Table 7: Test Results For 7 ETFs during 2008-2013 periods

iShares MSCI Malaysia Index Fund (EWM)

SPDR S&P China ETF (GXC)

Wisdom Tree Indian Rupee Fund (ICN)

Market Vectors Indonesia Index (IDX)

Market Vectors Russia ETF (RSX)

iShares MSCI Thailand Investable Market Index Fund (THD)

Market Vectors Vietnam ETF (VNM)
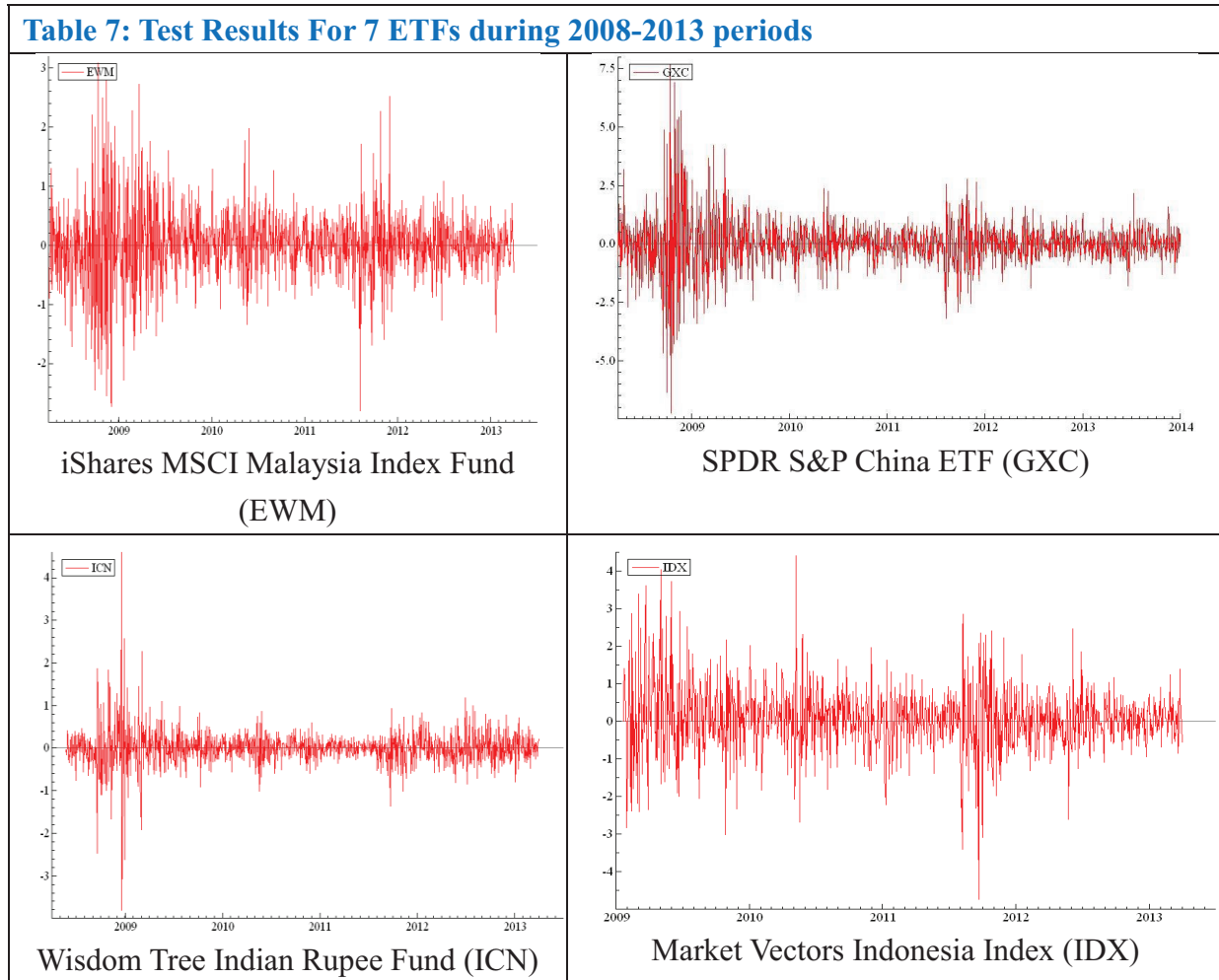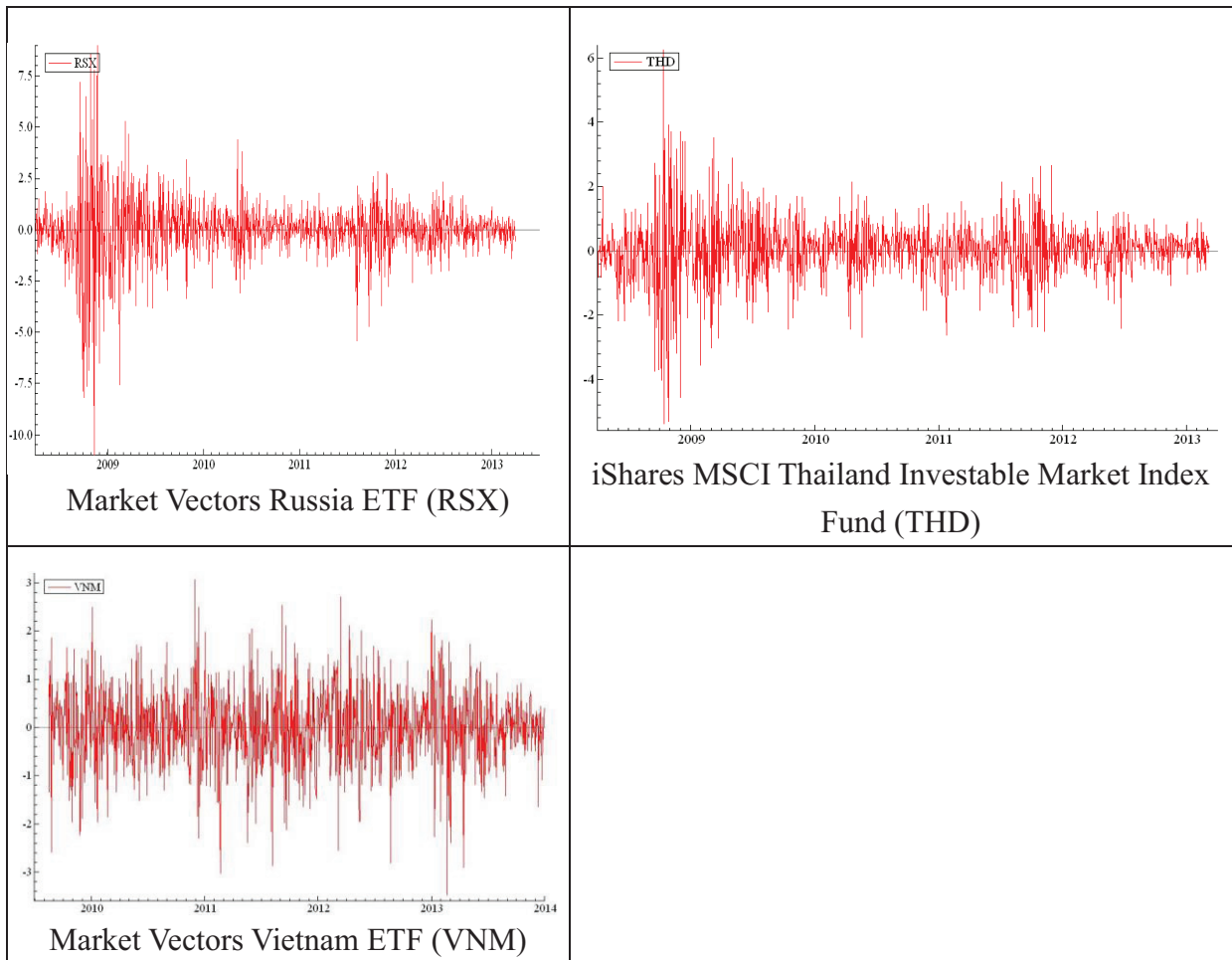
First of all, seven ETFs index data were all tested unit root. Then, ARMA model and EGARCH model were applied for them. In ADF test, the null hypothesis is "there is a unit root". The null hypothesis is tested and the results are given in the below table for the selected series. ADF statistics of seven ETFs are all negative or smaller than 0. It means the probability of the ETFs during the periods having unit root.

Table 8: Summary statistics of Unit-Root, ARMA, LM, and ARCH-LM tests for ETF returns					
Code	ADF	ARMA	AIC	LM	ARCH-LM
EWM	-42.39947	(1,2)	1.879896	0.236475	121.2391 (0.0000)***
GXC	-19.34147	(3,3)	2.92314	1.615338	294.2034 (0.0000)***
ICN	-23.09818	(2,3)	1.045957	3.710136	171.6569 (0.0000) ***
IDX	-17.41467	(3,3)	2.630493	2.877948	66.6525 (0.0000) ***
RSX	-27.34902	(2,2)	3.652500	7.013959	218.4240 (0.0000) ***
THD	-40.83453	(2,3)	2.738533	0.081348	139.1052 (0.0000) ***
VNM	-14.39410	(2,3)	2.421753	0.338294	18.96448 (0.0001) ***
Notes: t/z statistics in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%.					

The augmented Dickey-Fuller (ADF) statistics used in the test are negative numbers. The more negative it is, the stronger the rejection of the hypothesis that there is a unit roots at some level of confidence. In this case, with four lags, the models that include constants and time trends are estimated using sample of 1258 (EWM), 1449 (GXC), 1220 (ICN), 1054 (IDX), 1258 (RSX), 1243 (THD), and 1102 (VNM) observations and yields the DF statistic of -42.39947, -19.34147, -23.09818, -17.41467, -27.34902, -40.83453, and -14.39410 constituted rejections at the p-value of 0.01, 0.05 and 0.1 (or at the 1% level, 5% level and 10% level) the null hypothesis of a unit root will be rejected in a given time series.

The data is already stationary using no difference parameters and 4 lags, so we can just use ARMA. Significant value for the ADF is required. This means that the null hypothesis of the variable having a unit root/non-stationary is rejected. The significant result in ADF test shows that we can just use ARMA in modeling the data because we don't need to have an integrating or differencing parameter.

To model these time series observations dependence, ARMA (1,2) with the smallest AIC equal to 1.879896 is the best model for Malaysian ETF during the periods. ARMA (3,3) with the smallest AIC equal to 2.92314 is the best model for Chinese ETF during the periods. ARMA (2,3) with the smallest AIC equal to 1.045957 is the best model for Indian ETF during the periods. ARMA (3,3) with the smallest AIC equal to 2.630493 is the best model for Indonesian ETF during the periods. ARMA (2,2) with the smallest AIC equal to 3.652500 is the best model for Russian ETF during the periods. ARMA (2,3) with the smallest AIC equal to 2.738533 is the best model for Thailand ETF during the periods. ARMA (2,3) with the smallest AIC equal to 2.421753 is the best model for Vietnamese ETF during the periods. Indian ETF has the smallest AIC compare to the AIC values of the other six ETFs.

LM test probability values of Malaysian, Chinese, Thailand, Vietnamese ETFs are 0.236475, 1.615338, 0.081348, and 0.338294 all smaller than 1.96, accept the null hypothesis of no first order serial correlation up to lag order 2. The Serial correlation LM test result showed that there is serial correlation in all significance levels.

ARCH tests are applied to the residual series, to ensure that the null hypothesis of no ARCH effect is not rejected due to the failure of the pre-whitening linear models. The ARCH-LM tests up to lag order 2 are significant for all ETFs. The p-values' exceedance of zero indicates the acceptance of the null hypothesis of model adequacy at significance level 0.01. Thus, ARCH LM-tests indicate that volatility is serially correlated over time

Other ARCH models have also been estimated i.e. EGARCH model for the given time series. The estimation results are also given in the above table. EGARCH (3,2) is the variance equation in the estimated ARCH model for Malaysian ETF. EGARCH (3,2) is the variance equation in the estimated ARCH model for Chinese ETF. EGARCH (3,3) is the variance equation in the estimated ARCH model for Indian ETF. EGARCH (3,1) is the variance equation in the estimated ARCH model for Indonesian ETF. EGARCH (3,2) is the variance equation in the estimated ARCH model for Russian ETF. EGARCH (3,3) is the variance equation in the estimated ARCH model for Thailand ETF. EGARCH (2,3) is the variance equation in the estimated ARCH model for Vietnamese ETF. And again Indian ETF has the smallest AIC which equals to 0.588696 compare to the AIC values of the other six ETFs.

Table 9: Summary statistics of EGARCH model for ETF returns				
Code	EGARCH	AIC	ARCH-LM	Log-Likelyhood
EWM	(3,2)	1.534524	2.5975 (0.2729)	-2493.965
GXC	(3,2)	2.338004	4.291723 (0.1170)	-2787.449
ICN	(3,3)	0.588696	8.9307 (0.0115)	-2556.834
IDX	(3,1)	2.338950	2.9712 (0.2264)	-2066.975
RSX	(3,2)	2.944747	3.2055 (0.2013)	-2431.768
THD	(3,3)	2.333195	0.1976 (0.9059)	-2509.372
VNM	(2,3)	2.363355	1.001381 (0.6061)	-2132.123

After estimating ARCH models, ARCH-LM test has been used to see whether there is any further ARCH error in the series? The results were found that there was no evidence of any further ARCH in the given time series. The ARCH-LM values of seven ETFs are 2.597507 (EWM), 4.291723 (GXC), 8.930756 (ICN), 2.971245 (IDX), 3.205501 (RSX), 0.197600 (THD), and 1.001381 (VNM) (see table 9) for EGARCH model respectively and P-values of seven ETFs are smaller than 0.85, only Thailand ETF has the p-value of EGARCH model equal 0.9059 greater than 0.85 in this case for the given time series. This proves that there is no ARCH error remains in the given time series of Thailand ETF. The smallest value of AIC indicates best model. These statistics choose EGARCH model for the given time series. Log likelihood is maximizing for EGARCH model and show that it is the best model.

The most popular long memory model for levels $\{x_t\}$ is the ARFIMA (p,d,q), due to Hosking (1981) and Granger and Joyeux (1980). The FI in ARFIMA stands for "Fractionally Integrated". In other words, ARFIMA models are simply ARIMA models in which the d (the degree of integration) is allowed to be a fraction of a whole number, such as 0.4, instead of an integer, such as 0 or 1.

To identify the order of the ARIMA model, OxMetrics software (Oxmetrics 6.2) was used. ARFIMA (3,d,2) model for Malaysian and Indian ETFs, ARFIMA (2,d,3) for Chinese ETF, ARFIMA (3,d,1) for Indonesian ETF, ARFIMA (3,d,3) for Russian and Thailand ETFs, and ARFIMA (1,d,0) for Vietnamese ETFs. We already determined the order of d-parameter in ARIMA model, which are equal to 0.0215721 (EWM), -0.0599322 (GXC), -0.0850279 (ICN), 0.133201 (IDX), -0.0348419 (RSX), 0.0165658 (THD), and -0.0104116 (VNM) (see table 10).

According to the results in table 10, d-coefficient values of Malaysian ETF, Indonesian ETF, and Thailand ETF are greater than 0 and smaller than 0.5 so the long memory processes or the so-called positive dependence among remote observations exists. Besides, d-coefficient values of Chinese ETF, Indian ETF, Russian ETF, and Vietnamese ETF are greater than -0.5 but smaller than 0. So there is presence of intermediately memory or anti-persistence.

From the correlogram we observed that the best ARIMA model will be Maximum likelihood estimation of ARFIMA (3,d,2) model for Indian ETF (-634.406951) with the smallest AIC equal to 1.05312615, this AIC value is also the smallest value compare to the AIC values of the other five ETFs. The final estimation results for competing model for the given time series are given in the following table 10.

Table 10: Summary of ARFIMA statistics				
ARFIMA				
ETFs	**ARMA**	**d-coeff. (t-prob)**	**AIC**	**Log-likelihood**
EWM	(3,2)	0.0215 (0.470)	1.87796691	-1173.24119
GXC	(2,3)	-0.0599322 (0.088)	2.92897212	-2114.0403
ICN	(3,2)	-0.0850 (0.012)**	1.05312615	-634.406951
IDX	(3,1)	0.1332 (0.145)	2.64001997	-1384.29052
RSX	(3,3)	-0.0348 (0.180)	3.66139606	-2294.01812
THD	(3,3)	0.0165 (0.640)	2.73888908	-1693.21956
VNM	(1,0)	-0.0104116 (0.797)	2.43815793	-1339.42502
Notes: t/z statistics in brackets. * significant at 10%; ** significant at 5%; * significant at 1%.**				

The t-probability values are insignificant for all ETFs except Indian ETF (ICN). In short, from the above table we can conclude that AIC value of Indian ETF is the smallest that chooses ARFIMA (3,d,2) as the best model for the given time series. Log likelihood is also

going in favor of ARFIMA (3,d,2) model.

The estimated ARCH models were also compared for the series to check which model is the best model among the competing models. After comparison, the results showed that EGARCH model is the best model for the series. It is also important to note that ARCH models performed better than ARFIMA model in this case. For ARFIMA model, minimum value of AIC is 1.05312615 (ICN), while for EGARCH model, minimum value of AIC is 0.588696 (ICN) and for ARMA model, minimum value of AIC is 1.045957 (ICN).

Next, a simulation study was considered to evaluate the procedures for estimating the parameters of an ARFIMA-FIGARCH process

Table 11: Summary statistics of ARFIMA-FIGARCH					
ARFIMA-FIGARCH					
ETFs	d-coeff. (t-prob) d-Arfima	(p,q)	d-coeff. (t-prob) d-Figarch	AIC	Log-likelihood
EWM	-0.0237 (0.5548)	(3,0)	0.9943 (0.0000)***	1.561426	-970.137
GXC	-0.062303 (0.1599)	(3,3)	1.016139 (0.0000)***	2.351365	-1687.564
ICN	-0.0487 (0.4474)	(3,2)	0.6550 (0.0000)***	0.587584	-344.427
IDX	0.0777 (0.2899)	(2,3)	0.5995 (0.1347)	2.353628	-1227.362
RSX	0.1399 (0.2255)	(1,2)	0.7881 (0.0043)***	2.955224	-1845.836
THD	0.0198 (0.6817)	(1,2)	0.6110 (0.0002)***	2.344546	-1444.135
VNM	-0.039181 (0.4880)	(1,1)	0.340475 (0.0024)***	2.374542	-1301.373
Notes: t/z statistics in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%.					

In this step, ARFIMA (m,d,l) model was applied in combination with GARCH (p,q) orders to generalize ARFIMA-FIGARCH. As the results, Indian ETF has the smallest AIC which equals to 0.587584. The best model is ARFIMA (3,d,2). Estimation for d-Figarch is 0.6550.

So ARFIMA-FIGARCH (3,d,2) model of Indian ETF is the best model. Log-likelihood is also going in favor of the model. (See Table 11)

After all, ARFIMA-HYGARCH model was generalized.

Table 12: Summary statistics of ARFIMA-HYGARCH						
ARFIMA-HYGARCH						
ETFs	d-coeff. d-Arfima	(p,q)	d-coeff. d-Figarch	Log Alpha (HY)	AIC	Log-likelihood
EWM	-0.0243 (0.5712)	(1,2)	1.0345 (0.0000)***	-0.0080 (0.3339)	1.560100	-968.303
GXC	-0.097479 (0.0142)	(3,3)	1.112228 (0.0000)***	-0.007358 (0.4532)	2.346661	-1683.156
ICN	-0.0381 (0.5883)	(3,3)	0.6186 (0.0000)***	0.0125 (0.7916)	0.589476	-343.580
IDX	0.0909 (0.2349)	(3,3)	0.8059 (0.0000)***	-0.0374 (0.1068)	2.355170	-1226.175
RSX	0.1380 (0.2449)	(1,3)	0.7020 (0.0000)***	-0.0187 (0.4308)	2.957560	-1845.305
THD	0.0191 (0.6930)	(2,2)	0.5935 (0.0020)***	0.0003 (0.9931)	2.347269	-1443.827
VNM	-0.055067 (0.3061)	(0,1)	0.092488 (0.5114)	0.777785 (0.5422)	2.374924	-1301.583
Notes: t/z statistics in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%.						

According to the results in table 12, d-coefficient value of Indian ETF, Indonesian ETF, Russian ETF, Thailand ETF, and Vietnamese are equal to 0.618626 (ICN), 0.805914 (IDX), 0.702060 (RSX), 0.593500 (THD), and 0.092488 (VNM) which mean the differencing parameters d-Figarch dictate the long memory property of the volatility with a range of $0<d<1$ that allows for stronger volatility persistence. (See Table 12).

Which model performs better within four models that were estimated? To judge the performance of these models, these models were compared with each other and their forecast performances were also evaluated by using two statistics Akaike info criterion (AIC) and Log likelihood. The comparison and forecast evaluation results are given in the following table for

the estimated models. (See Table 13).

Table 13: Comparison and forecast evaluation of various models for 6 emerging ETFs				
ETFs	EGARCH	ARFIMA	ARFIMA-FIGARCH	ARFIMA-HYGARCH
AIC				
EWM	1.534524[*]	1.87796691	1.561426	1.560100
GXC	2.338004[*]	2.92897212	2.351365	2.346661
ICN	0.588696	1.05312615	0.587584[*]	0.589476
IDX	2.338950[*]	2.64001997	2.353628	2.355170
RSX	2.944747[*]	3.66139606	2.955224	2.957560
THD	2.333195[*]	2.73888908	2.344546	2.347269
VNM	2.363355[*]	2.43815793	2.374542	2.374924
Log-Likelihood				
EWM	-2493.965	-1173.24119	-970.137	-968.303[*]
GXC	-2787.449	-2114.0403	-1687.564	-1683.156[*]
ICN	-2556.834	-634.406951	-344.427	-343.580[*]
IDX	-2066.975	-1384.29052	-1227.362	-1226.175[*]
RSX	-2431.768	-2294.01812	-1845.836	-1845.305[*]
THD	-2509.372	-1693.21956	-1444.135	-1443.82[*]
VNM	-2132.123	-1339.42502	-1301.373[*]	-1301.583
Note: [*] indicate that the statistic choose the model among the competing models.				

Table 13 shows the comparison and forecast evaluation results of four estimated models for ETFs return of seven emerging markets series. From the statistics, EGARCH model performed better than other three models for Malaysian ETF (EWM), Chinese ETF (GXC), Indonesian ETF (IDX), Russian ETF (RSX), Thailand ETF (THD), and Vietnamese ETF (VNM). While ARFIMA-FIGARCH model performed better for only Indian ETF (ICN). AIC statistics choose EGARCH model among four estimated models as the best model for six out of seven variables. The smaller values of AIC indicate best model among the competing models. Besides, maximum Log likelihood statistics showed that ARFIMA-HYGARCH model is the best model for six variables Malaysian ETF (EWM), Chinese ETF (GXC), Indian ETF (ICN), Indonesian ETF (IDX), Russian ETF (RSX), and Thailand ETF (THD). Only ARFIMA-FIGARCH model performed better for Vietnamese ETF (VNM) in this case.

CONCLUSION

After achieving stationary by using unit root testing, we have used ARMA model and ARCH-LM test for seven ETFs series. Then, various models have been used for seven series to choose the best model. ARMA (1,2), ARMA (3,3), ARMA (2,3), ARMA (3,3), ARMA (2,2), ARMA (2,3), and ARMA (2,3) are the final models for Malaysian ETF (EWM), Chinese ETF (GXC), Indian ETF (ICN), Indonesian ETF (IDX), Russian ETF (RSX), Thailand ETF (THD), and Vietnamese ETF (VNM). After ARMA modeling, ARFIMA model and ARCH models were used to form the AIC as well as the log-likelihood. For this purpose, ARCH-LM test was applied firstly to test whether there is any ARCH error. The test results showed that there were ARCH errors in all series for ARMA model. Later, three different ARCH models, namely EGARCH, ARFIMA-FIGARCH and ARFIMA-HYGARCH models were used for seven series. After estimation of ARCH models ARCH-LM test was repeatedly used to test whether there was any further ARCH error in seven series. The test results showed that there was further ARCH error in Thailand ETF series after estimation of EGARCH models. The best model among the competing models was chosen within the estimated ARCH models for six series. The comparison results concluded that EGARCH model is the final competing model for six series, except Indian ETF (ICN) and ARFIMA-HYGARCH model is the competing models for six series, except Vietnamese ETF (VNM). These all models are good and can be used for forecasting, however, we made comparison and evaluate the forecast performance of these models to choose a single model among the competing models. The performances of asymmetric parameter were insignificant in all series except Indian ETF series in estimation of ARFIMA. The performances of asymmetric parameter are significant in all series, except Indonesian ETF (IDx), in estimations of ARFIMA-FIGARCH model and except Vietnamese ETF (VNM) in estimations of ARFIMA-HYGARCH model. It is important to note that ARCH models performed better than ARFIMA model in each case. Besides, the minimum values of AIC of six series felt in estimations of EGARCH model. In the opposite, the maximum values of log-likelihood of six series felt in estimations of ARFIMA-HYGARCH models.

REFERENCES

1. Aggarwal and Goodell, 2009. Markets versus institutions in developing countries: National attributes as determinants. Emerging Markets Review 10, 51–66.
2. Aggarwal, R. et al. 2007. "ADR holdings of US-based emerging market funds". Journal of Banking & Finance 31, 1649–1667.
3. Aggarwal, R., Goodell, J.W. 2009. "Markets versus institutions in developing countries:

National attributes as determinants". Emerging Markets Review 10, 51–66.

4. Aggarwal, R., Kearney, C., Lucey, B. 2012. "Gravity and culture in foreign portfolio investment". Journal of Banking and Finance 36 (2), 525–538.

5. Aloui, C., Jammazi, R. 2008. "The effects of crude oil shocks on stock market shifts behavior: a regime switching approach". Energy Economics 31, 789–799.

6. Altman, E.I. and Bana, G. 2003. "Defaults and Returns on High Yield Bonds: The Year 2002 in Review and the Market Outlook". NYU Working Paper No. FIN-03-010. Available at SSRN: http://ssrn.com/abstract=1298800

7. Assaf, A. 2006. "Dependence and mean reversion in stock prices: the case of the MENA region". Research in International Business and Finance, 20, 286–304.

8. Atkinson, T., Luttrell, D. and Rosenblum, H. 2013. "How Bad Was It? The Costs and Consequences of the 2007-09 Financial Crisis". Staff Papers, No.20, 1-18.

9. Aviat, A. and Coeurdacier, N. 2007. "The geography of trade in goods and asset holdings". Journal of International Economics 71, 22–51.

10. Baillie, R. T., Bollerslev, T., Mikkelsen, H. O. (1996a). Fractionally integrated generalized autoregressive conditional heteroskedasticity. *Journal of Econometrics, 74*, 3–30.

11. Baillie, R.T. and Morana, C. 2009. "Modelling long memory and structural breaks in conditional variances: An adaptive FIGARCH approach". Journal of Economic Dynamics & Control 33,1577–1592.

12. Baillie, R.T., Bollerslev, T., and Mikkelsen, H.O. 1996. "Fractionally integrated generalized autoregressive conditional heteroskedasticity". Journal of Econometrics, 74, 3–30.

13. Barkoulas, J.T., Baum, C.F., Travlos, N. 2000. "Long memory in the Greek stock market". Applied Financial Economics, 10, 177–184.

14. Beirne, J., Caporale, G.M., Schulze-Ghattas, M., and Spagnolo, N., 2009. "Global and regional spillovers in emerging stock markets: a multivariate GARCH-in-mean analysis". Economics and Finance Working Paper Series, Working Paper No. 09-34.

15. Beirne, J., Caporale, G.M., Schulze-Ghattas, M., Spagnolo, N., 2010. Global and regional spillovers in emerging stock markets: a multivariate GARCH-in-mean analysis. Emerging Markets Review 11, 250–260.

16. Bekaert, G. and Harvey, C.R. 1997. "Emerging Equity Market Volatility". Journal of Financial and Economics 43, 29-77.

17. Bekaert, G. and Harvey, C.R. 2000. "Foreign speculators and emerging equity markets". Journal of Finance 55, 565–613.

18. Bekaert, G., Erb, C.B., Harvey, C.R., Viskanta, T.E. 1997. "What matters for emerging market equity investments". Emerging Markets Quarterly, 17–46.

19. Bekaert, G., Harvey, C., 1997. Emerging equity market volatility. Journal of Financial Economics 43, 29–77.

20. Bekaert, G., Harvey, C.R., 1995. "Time-varying world market integration". Journal of Finance 50, 403–444.

21. Bekaert, G., Harvey, C.R., 2003. Emerging markets finance. Journal of Empirical Finance 10 (1), 3–55.

22. Bekaert, G., Harvey, C.R., Lumsdaine, R.L., 2002. "The dynamics of emerging market equity flows". Journal of International Money and Finance, 21 (3): 295–350.

23. Bekaerta, G., Harvey, C.R. 1997. "Emerging equity market volatility". Journal of Financial Economics 43(1): 29-77.

24. Berrill, J. and Kearney, C. 2011. "Investing in emerging and developing markets". In: Kent Baker, H., Riddick, Leigh A. (Eds.), Survey of International Finance, Oxford University Press.

25. Bleakley, H. and Cowan, K. 2010. "Maturity mismatch and financial crises: Evidence from emerging market corporations". Journal of Development Economics 93, 189–205.

26. Bleakley, H. and Cowan, K. 2010. "Maturity mismatch and financial crises: Evidence from emerging market corporations". Journal of Development Economics 93, 189–205.

27. Blitz, D. and Huij, J. 2012. "Evaluating the performance of global emerging markets equity exchange-traded funds". Emerging Markets Review 13, 149–158.

28. Bodart, V., Candelon, B., 2009. Evidence of interdependence and contagion using a frequency domain framework. Emerging Markets Review 10, 140–150.

29. Bollerslev, T. (1987). A conditionally heteroskedastic time series model for speculative prices and rates of return. *The Review of Economics and Statistics, 69*, 542–547.

30. Bollerslev, T. and Mikkelsen, H.O. 1996. "Modeling and pricing long memory in stock market volatility". Journal of Econometrics, 73, 151–184.

31. Borker, D. R. (2012). Accounting, Culture And Emerging Economies: IFRS In Central And Eastern Europe. International Business & Economics Research Journal, 11(9), 1003-1018.

32. Brana, S., Lahet, D., 2010. Determinants of capital inflows into Asia: the relevance of contagion effects as push factors. Emerging Markets Review 11, 273–284.

33. Brandao-Marques, L., Gelos, G., & Melgar, N. (2013). Country Transparency and the Global Transmission of Financial Shocks. *IMF Working Paper, 156*, 1-37.

34. Bruner, R.F., Conroy, R.M., Li, W., O'Halloran, E.F., Lleras, M.P. 2003. "Investing in emerging markets". The Research Foundation of AIMR.

35. Bruner, R.F., Conroy, R.M., Li, W., O'Halloran, E.F., Lleras, M.P., 2003. "Investing in emerging markets". The Research Foundation of AIMR. (100 pp).

36. Brunetti, C., Scotti, C., Mariano, R.S., Tan, A.H.H., 2008. Markov switching GARCH

models of currency turmoil in Southeast Asia. Emerging Markets Review 9, 104–128.

37. Bunda, I. et al. 2009. "Correlations in emerging market bonds: The role of local and global factors". Emerging Markets Review 10, 67–96.

38. Bunda, I., Hamann, A.J. and Lall, S. 2010. "Correlations in Emerging Market Bonds: The Role of Local and Global Factors". IMF Working Paper at http://www.imf.org/external/pubs/ft/wp/2010/wp1006.pdf

39. Canela, M.Á., Collazo, E.P. 2007. "Portfolio selection with skewness in emerging market industries" Emerging Markets Review 8, 230–250.

40. Canela, M.Á., Collazo, E.P. 2007. "Portfolio selection with skewness in emerging market industries" Emerging Markets Review 8, 230–250.

41. Cardamone, E. and Folkinshteyn, D. 2007. "HYGARCH Approach to Estimating Interest Rate and Exchange Rate Sensitivity of a Large Sample of U.S. Banking Institutions".

42. Chang, E.J., Lima, E.J.D., Tabak, B.M., 2004. "Testing for weak form efficiency in emerging markets". Emerging Market Review 3, 295–316.

43. Chiyachantana, C.N., Jain, P.K., Jiang, C., Wood, R.A., 2004. "International evidence on institutional trading behavior and price impact". Journal of Finance, 59 (2): 869–898.

44. Colm Kearney. 2012. "Emerging markets research: Trends, issues and future directions". Emerging Markets Review 13, 159–183.

45. Corsetti, G., Pesenti, P., and Roubini, N. 1999. "What Caused the Asian Currency and Financial Crisis?" Japan and the World Economy, 11, 305-373.

46. Davidson, J. 2003. "Moment and Memory Properties of Linear Conditional Heteroscedasticity Models, and a New Model".

47. Davidson, J. 2004. "Moment and memory properties of linear conditional heteroskedasticity models, and a new model". Journal of Business and Economic Statistics, 22, 16–29.

48. Davidson, J., (2004). Moment and memory properties of linear conditional heteroscedasticity models, and a new model. *Journal of Business and Economic Statistics, 22*, 16-29.

49. De la Torre, A., Yeyati, E.L., and Schmukler, S.L. 2002. "Argentina's Financial Crisis: Floating Money, Sinking Banking" (Washington: World Bank). At http://www.econ.umn.edu/~tkehoe/classes/Schmukler.pdf

50. De Santis, G., Gerard, B., 1997. "International asset pricing and portfolio diversification with time-varying risk". Journal of Finance 52, 1881–1912.

51. Dey, K.D. 2005. "Turnover and return in global stock markets". Emerging Markets Review, 6 (1): 45–67.

52. Ding, Z. and Granger, C.W.J. 1996. "Modeling volatility persistence of speculative returns: a new approach". Journal of Econometrics 73,185–215.

53. Domowitz, I., Glen, J., Madhavan, A., 2001. "Liquidity, volatility and equity trading costs across countries and over time". International Finance, 4 (2): 221–255.

54. Donadelli, M., Prosper, L. 2011. "The Equity Risk Premium: Empirical Evidence from Emerging Markets". CASMEF Working Paper Series, Working Paper No. 1, 1-49.

55. Dooley, M. and Hutchison, M. 2009. "Transmission of the U.S. subprime crisis to emerging markets: Evidence on the coupling-recoupling hypothesis". Journal of International Money and Finance 28, 1331-1349.

56. Edwards, S. and Savastano, M.A. 1998. "The morning after: The Mexican Peso in the Aftermath of the 1994 Currency Crisis". NBER Working Paper 6516, at http://www.anderson.ucla.edu/faculty/sebastian.edwards/W6516.pdf

57. Edwards, S., Susmel, R., 2003. Interest-rate volatility in emerging markets. The Review of Economics and Statistics 85, 328–348.

58. Elenkov, D. S. (1998). Can American Management Concepts Work in Russia? A Cross Cultural Comparative Study. *California Management Review, 40*(4), 133-156.

59. Engle, R. F. (2004). Risk and volatility: Econometric models and financial practice. *The American Economic Review, 94*(3), 405-420.

60. Fan, J.O.H.,Wei, K.C.J., Xu, X., 2011. Corporate finance and governance in emerging markets: a selective review and an agenda for future research. Journal of Corporate Finance 17 (2), 207–214.

61. Fan, J.P.H. et al. 2011. "Corporate finance and governance in emerging markets: A selective review and an agenda for future research". Journal of Corporate Finance 17, 207–214.

62. Fan, J.P.H., Wei, K.C.J, Xu, X.Z. 2011. "Corporate finance and governance in emerging markets: A selective review and an agenda for future research". Journal of Corporate Finance 17, 207–214.

63. Feridun, 2007. "An Econometric Analysis Of The Mexican Peso Crisis Of 1994-1995". Doğuş Üniversitesi Dergisi, 8 (1), 28-35. At http://journal.dogus.edu.tr/index.php/duj/article/download/96/112

64. Feridun, M. 2004. "Russian Financial Crisis of 1998: An Econometric Investigation". International Journal of Applied Econometrics and Quantitative Studies Vol.1-4(2004). At http://www.usc.es/economet/reviews/ijaeqs146.pdf

65. Fifield, S.G.M., Lonie, A.A., Power, D.M., Sinclair, C.D., 1999. Emerging markets: a disaggregated perspective on the gains from investing internationally diversified firms. Review of Pacific Basin Financial Markets and Policies 2 (1), 99–124.

66. Filippov, S. (2012). Emerging Russian multinational companies: managerial and corporate challenges. *European J. International Management, 6*(3), 323-341.

67. Flavin, T.J., Panopoulou, E., Unalmis, D., 2008. On the stability of domestic financial

market linkages in the presence of time-varying volatility. Emerging Markets Review 9, 280–301.

68. Floros, C., Jaffry, S., Lima, G.V. 2007. "Long memory in the Portuguese stock market". Studies in Economics and Finance, 24, 220–232.

69. Forbes, K.J. 2004. "The Asian flu and Russian virus: the international transmission of crises in firm-level data". Journal of International Economics, 63, 59–92.

70. Frank, N. and Hesse, H. 2009. "Financial Spillovers to Emerging Markets during the Global Financial Crisis". IMF Working Paper at http://www.financialmarketsjournal.co.za/13thedition/printedarticles/8a%20FinSpillovers%20to%20Emerging%20Ec%20During%20Global%20FinCrisis.pdf

71. Frank, N., González-Hermosillo, B. and Hesse, H., 2008. "Transmission of Liquidity Shocks: Evidence from the 2007 Subprime Crisis". IMF Working Paper at http://www.imf.org/external/pubs/ft/wp/2008/wp08200.pdf

72. Galbraith, J. W. & Zinde-Walsh, V. (2001). Autoregression-Based Estimators for ARFIMA Models. *JEL: C12, C22,* 1-12. ISSN 1198-8177.

73. Galbraith, J.W., and Zinde-Walsh, V. 2001. "Autoregression-Based Estimators for ARFIMA Models". CIRANO.

74. Ghemawat, P. & Reiche, S. 2011. National Cultural Differences and Multinational Business. *Globalization Note Series*. 1-18.

75. Giraitis, L., Kokoszka, P., Leipus, R. (2000). *Stationary ARCH models: dependence structure and central limit theorem. Econometric Theory, 16*, 3–22.

76. Griffith-Jones, S. 1997. "Causes and Lessons of the Mexican Peso Crisis". World Institute for Development Economics Research, Working papers No. 132 at http://www.stephanygj.net/papers/CausesandLessonsoftheMexicanPesoCrisis1997.pdf

77. Guest editorial. 2006. "Emerging markets finance: Overview of the special issue". Journal of International Money and Finance 25, 349-357.

78. Guillén, M.F. and Suárez, S.L. 2009. "The Global Crisis Of 2007-2009: Markets, Politics, And Organizations". Emerald Group Publishing Limited, Research in the Sociology of Organizations, 30, 257-279.

79. Hamilton, J.D., Susmel, R., 1994. Autoregressive conditional heteroscedasticity and changes in regime. Journal of Econometrics 70, 127–157.

80. Harvey, C. 1995. "Predictable risk and returns in emerging markets". Review of Financial Studies, 8 (3): 773–816.

81. Harvey, C.R., 1995. Predictable risk and returns in emerging markets. Review of Financial Studies 8, 773–816.

82. Hentschel, L. (1995). All in the family: Nesting symmetric and asymmetric GARCH models, *Journal of Financial Economics, 39*, 71–104.

83. Huang, R.R. 2007. "Distance and trade: disentangling unfamiliarity effects and transport cost effects". European Economic Review 51, 161–181.

84. IMF Working Paper No. 10, "Tequila Hangover: The Mexican Peso Crisis and Its Aftermath" at http://www.imf.org/external/pubs/ft/history/2012/pdf/c10.pdf

85. Ionascu, D., Meyer, K. E., & Erstin, S. (2004). Institutional Distance and International Business Strategies in Emerging Economies. *William Davidson Institute Working Paper, 728*, 1-41.

86. Jahan-Parvar, M.R. and Waters, G. 2009. "Equity Price Bubbles in the Middle Eastern and North African Financial Markets". MPRA Paper No. 17859, 1-18.

87. Johnston and Nedelescu, 2005. "The Impact of Terrorism on Financial Markets". IMF Working Paper, WP/05/60, 1-23. At http://www.mafhoum.com/press8/234E61.pdf

88. Jung, C.S. et al. 2009. "Can investor heterogeneity be used to explain the cross-section of average stock returns in emerging markets?" Journal of International Money and Finance 28, 648–670.

89. Kaminsky, G., Lizondo, S., and Reinhart, C.M. 1999. "Leading Indicators of Currency Crisis". IMF Staff papers, 45(1), 1-48. At http://www.imf.org/external/Pubs/FT/staffp/1998/03-98/pdf/kaminsky.pdf

90. Kanas, A. 2005. "Regime linkages between the Mexican currency market and emerging equity markets". Economic Modelling 22, 109–125.

91. Kanas, A., 2005. Regime linkages between the Mexican currency market and emerging equity markets. Economic Modelling 22, 109–125.

92. Kang, H.S. and Yoon, S.M. 2007. "Long memory properties in return and volatility: evidence from the Korean stock market". Physica A, 385, 591–600.

93. Kanga, SH. Yoon, SM. 2007. "Long memory properties in return and volatility: Evidence from the Korean stock market". Physica A 385, 591–600.

94. Kargin, V., 2002. "Value investing in emerging markets: risk and benefits". Emerging Markets Review 3 (3): 233– 244.

95. Karolyi, G.A. and Martell, R. 2010. "Terrorism and the Stock Market", International Review of Applied Finance Issues and Economics, 2(2): 285-314.

96. Kasman, A. et al. (2009). "Dual long memory property in returns and volatility: Evidence from the CEE countries' stock markets". Emerging Markets Review, 10, 122–139.

97. Kearney, C. 2012. "Emerging markets research: Trends, issues and future directions". Emerging Markets Review, 13, 159–183.

98. Kehoe, T.J. and Prescott, E.C. 2007. "What Can We Learn from the Current Crisis in Argentina?" Scottish Journal of Political Economy, 50 (2003), 609–33. [Revised version published as "What Can We Learn from the 1998–2002 Depression in Argentina?" Great Depressions of the Twentieth Century, Federal Reserve Bank of Minneapolis , 2007,

373–402].

99. Khilji, F., 2003. Financial crises in emerging markets: review. Journal of Economic Studies 30 (2), 169–182.

100. Kim, S.H., Kose, M.A., and Plummer, M.G. 2000. "Understanding the Asian Contagion: "An International Business Cycle Perspective"". The International Centre for the Study of East Asian Development, Working Paper Series Vol. 2000-14. At http://file.icsead.or.jp/user04/750_178_20110701150159.pdf

101. Klapper, L., Sulla, V., Vittas, D., 2004. "The development of mutual funds around the world". Emerging Markets Review, 5(1): 1–38.

102. Klapper, L.F. and Love, I. 2004. "Corporate governance, investor protection, and performance in emerging markets". Journal of Corporate Finance 10, 703–728.

103. Kokoszka, P., Leipus, R. (2000). Change-point estimation in arch models. *Bernoulli, 6*, 1–28.

104. Kortas M., L'Her J.F., Roberge M. 2005. "Country selection of emerging equity markets: benefits from country attribute diversification". Emerging Markets Review 6, 1 – 19.

105. Kortas, M. et al. 2005. "Country selection of emerging equity markets: benefits from country attribute diversification". Emerging Markets Review 6, 1–19.

106. Kraeussl, R. Logher, R. 2010. "Emerging art markets". Emerging Markets Review 11, 301–318.

107. Kwan, W., Li, W. K., & Li, G. (2012). On the estimation and diagnostic checking of the ARFIMA-HYGARCH model. *Computational Statistics & Data Analysis, 56*(11), 3632-3644.

108. Kwana, W., Li, W.K., Li, G.D. 2012. "On the estimation and diagnostic checking of the ARFIMA–HYGARCH model". Computational Statistics and Data Analysis, 56, 3632–3644.

109. Lagoarde-Segot, T. and Lucey, B.M. 2008. "Efficiency in emerging markets—Evidence from the MENA region" Int. Fin. Markets, Inst. and Money 18, 94–105.

110. Lang, M. H. & Maffett, M. G. (2011). Transparency and Liquidity Uncertainty in Crisis Periods. *Journal of Accounting & Economics (JAE), 52*(2-3), 101-125.

111. Li K. et al. 2003. "Diversification benefits of emerging markets subject to portfolio constraints". Journal of Empirical Finance 10, 57– 80.

112. Lien, D., Zhang, M., 2008. A survey of emerging derivatives markets. Emerging Markets Finance and Trade 44 (2), 39–69.

113. Limam, I. 2003. "Is long memory a property of thin stock markets? International evidence using Arab countries". Review of Middle East Economics and Finance, 1, 251–266.

114. Lucey, B.M. and Zhang, Q. 2010. "Does cultural distance matter in international stock

market comovement? Evidence from emerging economies around the world". Emerging Markets Review, 11, 62–78.

115. Melvin, M. and Taylor, M.P., 2009. "The Crisis in The Foreign Exchange Market". At http://www2.warwick.ac.uk/fac/soc/wbs/subjects/finance/confpapers09/melvintaylor_paper.pdf

116. Merrouche, O. and Nier, E. 2010. "What Caused the Global Financial Crisis?—Evidence on the Drivers of Financial Imbalances 1999–2007". IMF Working Paper at http://www.imf.org/external/pubs/ft/wp/2010/wp10265.pdf

117. Nakagawa, R., 2007. "Institutional development of capital markets in nine Asian economies". IDE Discussion Paper.

118. Naranjo A., Porter, B. 2007. "Including emerging markets in international momentum investment strategies". Emerging Markets Review 8, 147–166.

119. Naranjo, A. and Porter, B. 2007. "Including emerging markets in international momentum investment strategies". Emerging Markets Review 8, 147–166.

120. Naranjo, A. and Porter, B. 2007. "Including emerging markets in international momentum investment strategies". Emerging Markets Review, 8 (2): 147–166.

121. Nelson, D. B. (1991). Conditional Heteroskedasticity in Asset Returns: a New Approach. *Econometrica, 59*(2), 347-370.

122. Nelson, D.B. (1989). Modeling stock market volatility, Proceedings of the American Statistical Association. *Business and Economic Statistics Section*, 93–98.

123. Nelson, D.B. (1990). Conditional heteroskedasticity in asset pricing: A new approach. *Econometrica, 59*, 347–370.

124. Nelson, D.B. 1991. "Conditional heteroskedasticity in asset returns: a new approach". Econometrica, 59, 347–370.

125. Niguez, T. M. & Rubia, A. (2006). Forecasting the conditional covariance matrix of a portfolio under long-run temporal dependence. *Journal of Forecasting, 25*, 439-458.

126. Pagan, A. R, & Schwert, G. W. (1990). Alternative models for conditional stock volatility, *Journal of Econometrics, 45*, 267–290.

127. Phylaktis, K. and Xia, L. 2006. "Sources of firms' industry and country effects in emerging markets". Journal of International Money and Finance, 25 (3): 459–475.

128. Phylaktis, K., 2006. Emerging markets finance: overview of the special issue. Journal of International Money and Finance 25 (3), 349–357.

129. Pinegar J.M. and Ravichandran R. 2010. "Raising capital in emerging markets with restricted Global Depositary Receipts". Journal of Corporate Finance 16, 622–636.

130. Radelet, S. and Sachs, J. 1998. "The East Asian Financial Crisis: Diagnosis, Remedies, Prospects", Brookings Paper, 28(1): 1-74. At http://www.nber.org/papers/w6680

131. Rapp, J. K., Bernardi, R. A., & Bosco, S. M. (2011). Examining The Use of Hofstede's

Uncertainty Avoidance Construct in International Research: A 25-Year Review. *International Business Research, 4*(1), 3-15.

132. Reilly, F.K., Wright, D.J., and Gentry, J.A. 2009. "Historic Changes in the High Yield Bond Market". A Morgan Stanley Publication, Journal of Applied Corporate Finance 21(3), 65-79.

133. Rocha, K., Moreira, A. 2010. "The role of domestic fundamentals on the economic vulnerability of emerging markets". Emerging Markets Review 11, 173–182.

134. Saleem, 2009. "International linkage of the Russian market and the Russian financial crisis: A multivariate GARCH analysis". Research in International Business and Finance, 23(3): 243–256.

135. Schuler, K. 2005. "Ignorance and Influence: U.S. Economists on Argentina's Depression of 1998-2002". Econ Journal Watch, 2(2): 234-278.

136. Sourial, M.S. 2002. "Long memory process in the Egyptian stock market returns". Journal of Development and Economic Policy, 5, 65–88.

137. Suleman, M.T. 2012. "Stock Market Reaction to Terrorist Attacks: Empirical Evidence from a Front Line State". Australasian Accounting Business and Finance Journal, 6(1): 15, 97-110.

138. Swedberg, R. 2010. "The Structure Of Confidence And The Collapse Of Lehman Brothers". Emerald Group Publishing Limited, Research in the Sociology of Organizations, 30A, 71-114.

139. Tai, C.-S. 2007. "Market integration and contagion: Evidence from Asian emerging stock and foreign exchange markets". Emerging Markets Review 8, 264–283.

140. Tai, C.S., 2007. Market integration and contagion: evidence from Asian emerging stock and foreign exchange markets. Emerging Markets Review 8, 264–283.

141. Tang, T. L., & S. J. Shieh. (2006). Long memory in stock index future markets: a value-at-risk approach. *Physica A, 366*, 437-448.

142. Tang, T.L. and Shieh, S.J. 2006. "Long memory in stock index futures markets: A value-at-risk approach". Physica A, 366, 437–448.

143. Tayefi, M. and Ramanathan, T.V. 2012. "An Overview of FIGARCH and Related Time Series Models". Austrian Journal of Statistics, 41 (3): 175–196.

144. Truman, E.M. 1996. "The Mexican Peso Crisis: Implications for International Finance". Federal Reserve Bulletin, at http://www.federalreserve.gov/pubs/bulletin/1996/396lead.pdf

145. Voros, T., & Choudrie, J. (2011). *Uncertainty Avoidance and Technology Acceptance in Emerging Economies: A Comparative Study*. Paper presented at the SIG Globdev 4th Annual conference Shanghai, China.

146. Walid, C. et al. 2011. "Stock market volatility and exchange rates in emerging countries:

A Markov-state switching approach". Emerging Markets Review 12, 272–292.

147. Walid, C., Chaker, A., Masood, O. and Fry, J. 2011. "Stock market volatility and exchange rates in emerging countries: A Markov-state switching approach". Emerging Markets Review 12, 272–292.

148. Wang, P., Theobald, M. 2008. "Regime-switching volatility of six East Asian emerging markets". Research in International Business and Finance 22, 267–283.

149. Wang, P., Theobald, M., 2008. Regime-switching volatility of six East Asian emerging markets. Research in International Business and Finance 22, 267–283.

150. Whitt, Jr. J.A. 1996. "The Mexican Peso Crisis". Economic Review, Federal Reserve Bank of Atlanta, at http://www.frbatlanta.org/filelegacydocs/J_whi811.pdf

151. Wong, Y.C.R. 1999. "Lessons from the Asian Financial Crisis". Cato Journal, 18(3): 391-398.

152. Wright, J.H. 2001. "Long Memory in Emerging Market Stock Returns". Emerging Markets Quarterly, 5(3): 50–55.

153. Zaffaroni, P. (2004). Stationarity and memory of ARCH(∞) models. *Econometric Theory, 20*, 147–160.

154. Conrad, C. & M. Karanosos. (2005). On the Inflation-Uncertainty Hypothesis in the USA, Japan, And The UK: A Dual Long Memory Approach. *Japan and the World Economy, 17*, 327-343.

155. Beine, M., Laurent, S., & Lecourt, C. (2002). Accounting For Conditional Leptokurtosis and Closing Days Effects in FIGARCH Models of Daily Exchange Rates. *Applied Financial Economics, 12*, 589-600.

156. Nagayasu, J. (2003). The Efficiency of the Japanese Equity Market. *International Finance Review, 4*, 155-171.

157. Kang, S. H. & Yoon, S. M. 2012. Dual Long Memory Properties with Skewed and Fat-Tail Distribution. *International Journal of Business and Information, 7*(2), 225-249.

158. Cheong, C. W. (2007). A generalized discrete-time long memory volatility model for financial stock exchange. *American Journal of Applied Sciences, 4*(12), 970- 976.

159. Caporin, M. & Pres, J. (2009). Forecasting temperature indices with time varying long-memory models. *Marco Fanno working paper, N.88*, 1-58.

160. Fiszeder, P. (2006). Modeling financial processes with long memory in mean and variance. *Dynamic econometric models, 7*, Nicolaus Copernicus university.

161. Korkmaz, T., Cevik, E. I., Ozatac, N., (2009a). Testing for Long Memory in ISE Using ARFIMA-FIGARCH Model and Structural Break Test. *International Research Journal of Finance and Economics, 26*, 186-191.

162. Sivakumar, P. B. & Mohandas, V. P. (2009). Modeling and Predicting Stock Returns using the ARFIMA-FIGARCH: A case study on Indian Stock data. *Nature &*

Biologically Inspired Computing, 896-901.

163. Kasman, A. & Torun, E. (2007). Long Memory in the Turkish Stock Market Return and Volatility. *Central Bank Review, 2*, 13-27.

164. Chokethaworn, K., Wiboonponse, A., Sriboonchitta, S., Sriboonjit, J. Chaiboonsri, C., & Chaitip, P. (2010). International Tourists' Expenditures in Thailand: A Modelling Of The Arfima-Figarch Approach. *Annals of the University of Petroşani, Economics, 10*(2), 85-98.

165. Chokethaworn, K., Sriwichailamphan, T., Sriboonchitta, S., Chaiboonsri, C., Sriboonjit, J., & Chaitip, P. (2010). International Tourist Arrivals In Thailand: Forecasting With Arfima-Figarch Approach. *Annals of the University of Petroşani, Economics, 10*(2), 75-84.

166. Korkmaz, A., Celik, S., & Sevil, G. (2009). *Long Memory in Stock Markets: Empirical Study on Spot and Future Markets in Turkey*. International Conference-Las Vegas 2011.

167. Sandu, M. (2009). *Exploring Dual Long Memory in Returns and Volatility Across Central and Eastern Europe Stock Markets*. Academy Of Economic Studies Bucharest. Dissertation Paper, 1-48.

THE CORRELATION AMONG CALL-CENTER EMPLOYEES' INTEGRATED SCHEDULING, WORK STRESS AND JOB SATISFACTION─A CASE STUDY OF ONE TELECOM COMPANY

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ABSTRACT

Purpose: *This research first aimed to study the correlation between call-center employees' work stress and job satisfaction. Furthermore, it studied whether the introduction of integrated scheduling system influence employees' work stress.*

Design/methodology/approach: *The research subjects were call-center employees at one Telecom company. After questionnaires collection, all samples conducted statistical analysis on the verification of reliability, validity, as well as cause and effect. There were total 400 questionnaires issued and 308 ones returned, namely the valid response rate was 93.84%. The collected data were analyzed with various verifications methods, such as factor analysis, canonical correlation analysis and multiple regression method.*

Findings: *(1) There was a significant correlation between integrated scheduling system and work stress; (2) There was a significant correlation between integrated scheduling system and job satisfaction; (3) There was a significant correlation between call-center employees' work stress and job satisfaction.*

Originality/Value: *Our findings serve as the quantitative basis for the Telecom company to implement its proper strategies to improve its employee's satisfaction as well as their*

cohesion to the organizational objectives and development.

Keywords: work stress, job satisfaction, integrated scheduling

INTRODUCTION

The telecommunications services in Taiwan flourish in the last few years, government acts an active role in promoting the infrastructure of communication and broadband networks; reinforce innovation and application services and telecommunications liberalization. The widespread cell phone brings people the convenience, making its business grew rapidly. Based on the statistics from National Communications Commission (NCC), the penetration rate of cell phone in 2007 reached 105.8%, namely the average Taiwanese has more than one cell phone.

The telecommunications industry is always one of the popular industries regardless of economic cycle. In Taiwan's related literatures, there are accordingly numerous studies with focus on its employee performance, customer's consumption behaviors or operational performance. As a result, this research aims to study telecommunications industry from the perspective of call-center employees on cell phone business.

The objectives of this research are as follows: (1) The correlation between integrated scheduling and call-center employees' work stress; (2) The correlation between integrated scheduling and call-center employees' job satisfaction; (3) The correlation between call-center employees' work stress and job satisfaction. The analysis results will be references for the development of related industries.

LITERATURE REVIEW

The current condition of call-center in one telecom company

The call center consists of telephone, computer and customer-service staff. Among the three main elements, customer-service staff is the key to success because of their increasing importance. The call center nowadays substitutes previous computer-telephony customer service with customer-service staff. This trend means the current orientation return to the service conception with humanity, intimacy and high quality. With the integration platform of the three parties (telephone, computer system and outstanding staff), the call center acts single counter online to provide customer the convenient service "Just one call, solve the whole problem".

The implantation of integrated scheduling plan will maximize the scheduling efficiency and human-resource usage; decrease the human cost on duty; enhance customer service quality and customer satisfaction. Through the integrated scheduling plan among three shifts, this project is first expected to decrease manpower on duty and further the human cost. Later, the more abundant time will be used to reinforce training and guidance, as well as improve overall service quality. In order to decrease the waste in human resource and enhance the competitiveness of call center, the ultimate project goal is to output the maximum efficiency by the minimal manpower.

The definition and measurement of job satisfaction

The concept of job satisfaction was first posed by Hoppock (1935). In his definition, job satisfaction meant a worker is mentally and physically satisfied with environmental factors, namely the worker's subjective responses towards job context.

Hoppock (1935) thought job satisfaction should include five factors: job interest, expectation, workload, benefits, development and so on. Morris and Venkatesh (2010) claimed job satisfaction refers to employees' satisfaction degree towards their jobs.

Regarding the job satisfaction scale, the categories below are usually used by most scholars nowadays:

(1) Hoppock Job Satisfaction Scale: it infers subject's job satisfaction by measuring individual's perception on the reference objects.
(2) Index of Job Satisfaction: it measures employee's general job satisfaction.
(3) Job Description Index (JDI): With total 72 questions included; this scale is also equipped with 5 independent satisfaction scales on salary, promotion, the job itself, supervisor and colleague aspects. People can obtain the scores for overall job satisfaction by adding all scores together from these five small scales.
(4) Need satisfaction questionnaire (NSQ): it is designed based on the developmental theory of satisfaction.

Definition of work stress and its evaluation models

Following the M-shape society and dramatic price increase, these all makes people not only suffer unprecedented anxiety on jobs but also have increasing work stress as the world changes. In the organizational behavior, the first validation on stress through scientific method was pioneered by Seley (1956). He brings the term "Stress" into the fields of social science, believing stress is generated for any demands. As for the specific stress on job, Kahn *et al.* (1964) first began to explore the stress issues at work by introducing the management

theory of stress management in business management.

Cooper and Cartwright (1997) presented the six work stress sources in the process model of work stress change: (1) The job itself: physical working environment, work overtime, time pressure, business trip, new techniques, workload. (2) The role of the organization: role ambiguity, role conflict, responsibility. (3) Relationships at work: the relation among supervisor, subordinates and colleagues. (4) Career development: job security, job performance. (5) Organizational structure and atmosphere: sense of belonging, the participation of decision-making opportunity communication channel. (6) Non-work factors: financial situation, family support, etc.

The theoretical models for the work stress proposed by Cavaiola *et al.* (2012) are summarized as below:

(1) S-R Model: Excluding the issues on individual trait and the differentiation of perceptual reaction, it merely discusses the stimulus generated at workplace, which makes worker must change with it. The coping methods are changes of physical activity, the adjustment of psychology emotion and the response of behavior reaction.

(2) Interaction Model: It emphasizes the differentiation of individual trait. Stimulus at workplace brings people different acceptance and reactivity, instead of a simple connection between stimulus and response.

(3) Person-Environment Fit Model: By pointing out the fitness between individual and environment, it accordingly decides the stress or degree of oppression people experienced. It emphasizes the important role of individual trait during the process of job stress.

(4) Managerial-Oriented stress model: Robbins (1989) divided stressors into three items: individual, the interior of organization and the external environment. Under the influence of the extraneous variable among individual differences, people feel stressed, then have the results of psychological, physical and behavioral symptoms. In general, such model is more mature and complete.

RESEARCH METHOD

Research design

This research first distributed 20 informal questionnaires to call-center employee at a Telecom company by convenient sampling, and then retrieved 20 valid ones. Based on objects' feedbacks, adjusted the appropriateness of questionnaire and finalized the questionnaires after discussion with professor. Later, it distributed the formal ones for

subjects to fill based on their business experiences.

Analysis method

The analysis method is made based on the consideration of both research purpose and the hypothesis of research verification. After artificial questionnaire survey and encoding, all valid questionnaires retrieved were categorized by the SPSS 18.0. The analysis method is as below:

The variable of subjects' statistics

The research utilized participants' personal data to apply frequency distribution and percentage analysis on sample distribution. Then, it explained sample feature, and further understand their central tendency in each dimension.

Factor analysis

In order to seek research variables involved in the sub-dimension, factor analysis is used by the research to acquire the maximal variance by the most minimal principal components. During the factor analysis, principle component analysis was utilized to extract the common factors. Meanwhile, the factor with Eigenvalue above 1 was selected to conduct orthogonal rotation by Varimax. As for the factor with loading above 0.3 showed its significance, the research utilized it to understand its factor structure and reduce dimensions in each scale, which further enhances the construct validity of research questionnaire. Focusing on questions like integrated scheduling, work stress and job satisfaction, this part extracted the common factors based on the principal component factor analysis. The factors were consequently simplified to less dimensions, such results can be used for the subsequent analysis.

Canonical correlation analysis

Canonical correlation is applied to study correlation between the linear combination of several criterion variables and predicted variables. This part accordingly studies the correlation of the following two-dimension combinations: (1) Integrated scheduling and work stress. (2) Integrated scheduling and job satisfaction. (3) Work stress and job satisfaction.

Regression analysis

The research applied multiple regression analysis to integrate the correlation of the three combinations: (1) Integrated scheduling and work stress. (2) Integrated scheduling and job satisfaction. (3) Work stress and job satisfaction. As a result, the research found that the explanation and influence of each factor.

THE RESULTS OF DATA ANALYSIS

The analysis between integrated scheduling and work stress

This part conducted canonical correlation by selecting the four integrated scheduling factors as predicted variables and the two work stress variables as criterion variables. The selection standard of the research includes: Eigenvalues is greater than 0.1, p value is less than 0.05, canonical correlation squared is greater than 0.2. As data shown in the Table 1 below, only the first group of canonical correlation is discussed in a variate model equation while its canonical correlation coefficient is 0.459. According to the canonical correlation analysis, the research will further explore the correlation of two dimensions:

(1) The canonical loading of item "Fairness and efficiency" from the integrated scheduling variables and the 3 factors in work stress was negative; this indicates call-center employees show lower work stress on item "The stress of depression and fatigue", "The stress of anxiety" and "Low self-esteem stress" when they feel the integrated scheduling is fair and efficient.. Meanwhile, the canonical loading of item "Scheduling time" and "Negative effect" from the integrated scheduling variables and the 3 factors in work stress was positive; this indicates call-center employees show higher work stress on item "The stress of depression and fatigue", "The stress of anxiety" and "Low self-esteem stress" when the following two circumstances occur: (1) Call-center employees tend to have a negative thinking on the integrated scheduling policy or (2)Work time greatly affects their emotion at work or job performance.

(2) In the aspect of integrated scheduling, item "Fairness and efficiency" showed the highest explanation (-0.741) while its canonical loading reached 0.7 above. As for the aspect of work stress, item "Low self-esteem stress" showed the highest explanation (0.606) while its canonical loading reached 0.6 above. From this analysis, it can be inferred that there is a highly negative correlation between item "Fairness and efficiency" and "Low self-esteem stress." This indicates call-center employees' low self-esteem stress is decreasingly low when they feel fair and efficient about the integrated scheduling system.

The research set the four items "Fairness and efficiency", "Negative effect", "Scheduling time" and "Human downsizing" in integrated scheduling variables as independent variables. Besides, work stress was applied for multiple regression analysis by dependent variable, in order to verify the effect of four listed items on work stress.

Table 1 The verification table of canonical correlation on integrated scheduling and work stress

Canonical correlation equation	Eigenvalue	Variance percentage	Cumulative variance percentage	Canonical correlation coefficient	Canonical correlation coefficient squared	F value	P value
1	0.267	70.15%	70.15%	0.459	0.211	10.20	0.000
2	0.110	28.96%	99.11%	0.315	0.099	06.16	0.000
3	0.003	00.89%	100.00%	0.058	0.003	00.56	0.570

The multiple regression analysis must be fully aware of collinarity issue; hence VIF value is frequently used as verification index for collinarity diagnosis. To avoid each regression equation appeared collinarity problem, the research thus utilized the variance inflation (VIF) of parameter estimate for verification. The results discovered the VIF of each regression equation was smaller than 10, which means multicollinearity problem among each variable is not a serious concern. On the other hand, the research also measured the explanation of independent variable on dependent variable by R^2 value. As illustrated in Table 2 below, a correlation exists between the integrated scheduling variables and job satisfaction. The empirical results also found item "Fairness and efficiency" and "Human downsizing" showed insignificant effect on work stress. Moreover, there was a positive correlation between item "Negative effect ($\beta = 0.169$)" and work stress. This indicates call-center employees show higher work stress when they have a negative thinking on the integrated scheduling policy. Similarly, a positive correlation existed between item "Scheduling time ($\beta = 0.077$)" and work stress variables. This indicates call-center employees have higher work stress when their work time greatly affects emotion at work or job performance.

Table 2   The table of multiple regression coefficient on the integrated scheduling and work stress

	Independent variable	Regression coefficient	VIF value	R^2 value	F value	P-Value
Dependent variable: work stress	Constant	2.220				0.000
	Fairness and efficiency of integrated scheduling	-0.006	1.065			0.895
	Negative effect of integrated scheduling	0.169	1.150	0.68	7.213	0.000
	Scheduling time of integrated scheduling	0.077	1.101			0.048
	Human downsizing of integrated scheduling	-0.049	1.041			0.240

The analysis between the integrated scheduling and job satisfaction

This part conducted canonical correlation analysis by selecting the four integrated scheduling factors as predicted variables and the two job satisfaction variables as criterion variables. The selection standard in the research included: Eigenvalues is greater than 0.1, p value is less than 0.05, canonical correlation squared is greater than 0.2. As data shown in the Table 3 below, only the first group of canonical correlation is discussed in a variate model equation while its canonical correlation coefficient is 0.474. According to the canonical correlation analysis, the research will further explore the correlation of two dimensions:

(1) The canonical loading of item "Negative effect" from the integrated scheduling variables and the two factors from job satisfaction was negative; this indicates call-center employees show lower job satisfaction on item "Intrinsic satisfaction" and "Extrinsic satisfaction" when they have an increasingly negative thinking on the integrated scheduling policy. Meanwhile, the canonical loading of item "Fairness and efficiency" from integrated scheduling variables and the two factors from job satisfaction variables was positive. This indicates call-center employees show higher job satisfaction on item "Intrinsic satisfaction" and "Extrinsic satisfaction" when they feel the integrated scheduling policy is fair and efficient.

(2) In the aspect of integrated scheduling, item "Fairness and efficiency" showed the highest explanation (-0.851) while its canonical loading reached 0.8 above. As for the aspect of job satisfaction, item "Extrinsic satisfaction" showed the highest explanation (0.912) while its canonical loading reached 0.9 above. From this analysis, it can be inferred that there is a highly positive correlation between item "Fairness and efficiency" and "Extrinsic satisfaction". This indicates call-center employees' extrinsic satisfaction is increasingly high when they feel fair and efficient about integrated scheduling system.

Table 3   The verification table of canonical correlation on integrated scheduling and job satisfaction

Canonical correlation equation	Eigenvalue	Variance percentage	Cumulative variance percentage	Canonical correlation coefficient	Canonical correlation coefficient squared	F value	P value
1	0.289	68.01%	068.01%	0.474	0.224	16.38	0.000
2	0.136	31.98%	100.00%	0.346	0.120	14.18	0.000

The research set the four items "Fairness and efficiency", "Negative effect", "Scheduling time" and "Human downsizing" in integrated scheduling variables as independent variables. Besides, job satisfaction was applied for multiple regression analysis by dependent variable, in order to verify the effect of four listed items on job satisfaction.

To avoid each regression equation appear collinearity problem, the research thus utilized the variance inflation (VIF) of parameter estimate for verification. The results discovered the VIF of each regression equation was smaller than 10, which means multicollinearity problem among each variable is not a serious concern. On the other hand, the research also measured the explanation of independent variable on dependent variable by R^2 value. As illustrated in Table 4 below, a correlation exists between the integrated scheduling variables and job satisfaction. The empirical results also found item "Human downsizing" showed less effect on job satisfaction. Moreover, there was a negative correlation between item "Negative effect (β = -0.164)" and job satisfaction. This indicates call-center employees show lower job satisfaction when they have an increasing negative thinking on the integrated scheduling policy. Similarly, a negative correlation existed between item "Scheduling time (β = -0.072)" and job satisfaction variables. This indicates call-center employees have lower job satisfaction when their work time greatly affects emotion at work or job performance. Besides, there was a positive correlation between item "Fairness and efficiency (β = 0.239)" and job satisfaction variables. This indicates call-center employees show high job satisfaction when they feel fair and efficient about the integrated scheduling system.

The analysis between work stress and job satisfaction

This part conducted canonical correlation analysis by selecting the three integrated scheduling factors as predicted variables and the two job satisfaction variables as criterion variables. The selection standard of the research included: Eigenvalues is greater than 0.1; p value is less than 0.05; canonical correlation squared is greater than 0.2. As data shown in the Table 5 below, only the first group of canonical correlation is discussed via variate model

equation while its canonical correlation coefficient is 0.569.

Table 4 The table of multiple regression coefficient on the integrated scheduling and job satisfaction

	Independent variable	Regression coefficient	VIF value	R^2 value	F value	P-Value
Dependent variable: job satisfaction	Constant	2.781				0.000
	Fairness and efficiency of integrated scheduling	0.239	1.086			0.000
	Negative effect of integrated scheduling	-0.164	1.215	0.224	22.616	0.000
	Scheduling time of integrated scheduling	-0.072	1.180			0.032
	Human downsizing of integrated scheduling	0.032	1.047			0.355

According to the results of canonical correlation analysis, the research will further explore the correlation of two dimensions:

(1) The canonical loading of item "The stress of depression and fatigue" from the integrated scheduling variables and the two factors in job satisfaction was negative; this indicates call-center employees show higher job satisfaction on items "Intrinsic satisfaction" and "Extrinsic satisfaction" when they have lower stress of depression and fatigue. Meanwhile, the canonical loading of item "Low self-esteem stress" from work stress variables and the two factors in job satisfaction was negative; this indicates call-center employees show higher job satisfaction on item "Intrinsic satisfaction" and "Extrinsic satisfaction" when they have low self-esteem stress.

(2) In the aspect of work stress, item "The stress of depression and fatigue" showed the highest explanation (-0.856) while its canonical loading reached 0.8 above. As for the aspect of job satisfaction, item "Intrinsic satisfaction" showed the highest explanation (0.976) while its canonical loading reached 0.9 above. From this analysis, it can be inferred that there is a highly positive correlation between item "Fairness and efficiency" and "Extrinsic satisfaction". This indicates call-center employees show increasingly high extrinsic satisfaction when they feel fair and efficient about the integrated scheduling system.

Table 5   The verification table of canonical correlation on work stress and job satisfaction

Canonical correlation equation	Eigenvalue	Variance percentage	Cumulative variance percentage	Canonical correlation coefficient	Canonical correlation coefficient squared	F value	P value
1	0.478	74.07％	074.07％	0.569	0.323	32.68	0.000
2	0.167	25.92％	100.00％	0.378	0.143	26.24	0.000

The research set the three items "The stress of depression and fatigue", "The stress of anxiety" and "Low self-esteem stress" in integrated scheduling variables as independent variables. Besides, job satisfaction was applied for multiple regression analysis by dependent variable, in order to verify the effect of three listed items on job satisfaction.

To avoid each regression equation appeared collinearity problem, the research thus utilized the variance inflation (VIF) of parameter estimate for verification. The results discovered the VIF of each regression equation was smaller than 10, which means multicollinearity problem among each variable is not a serious concern. On the other hand, the research also measured the explanation of independent variable on dependent variable by R^2 value. As illustrated in Table 6 below, a correlation exists between the work stress variables and job satisfaction. The empirical results also found item "The stress of depression and fatigue (β = -0.219)" showed less effect on job satisfaction. This indicates call-center employees show lower job satisfaction when they have higher stress of depression and fatigue. Similarly, there was a negative correlation between item "The stress of anxiety (β = -0.115)" and job satisfaction variables. This indicates call-center employees show lower job satisfaction when they have higher stress of anxiety. Besides, a negative correlation existed between item "Low self-esteem stress (β = -0.273)" and job satisfaction variables. This indicates call-center employees have lower job satisfaction when they show higher low self-esteem stress.

Table 6 The table of multiple regression coefficient on work stress and job satisfaction

	Independent variables	Regression coefficient	VIF value	R^2 value	F value	P-Value
Dependent variable: job satisfaction	Constant	4.496				0.000
	The stress of depression and fatigue	-0.219	1.424	0.309	46.805	0.000
	The stress of anxiety	-0.115	1.277			0.001
	Low self-esteem stress	-0.273	1.301			0.000

CONCLUSIONS AND SUGGESTIONS

Empirical results

As all stated above, this research mainly studied the correlation among call-center employees' integrated scheduling, work stress and job satisfaction. After the empirical analyses, the conclusions are as follows:

(1) There was a significant correlation between integrated scheduling system and work stress.

(2) There was a significant correlation between integrated scheduling system and job satisfaction.

(3) There was a significant correlation between call-center employees' work stress and job satisfaction.

Research conclusions

After the empirical analysis, the research results are described below. This section will collect the test results of research hypotheses, as shown in Table 7:

Table 7- Summary of hypothesis tests

Research hypothesis	Test results
H1 The integrated scheduling shows a significant effect on call-center employees' work stress:	Inacceptable
H1-1 "Fairness and efficiency" shows a significant effect on call-center employees' work stress	Inacceptable
H1-2 "Negative effect" shows a significant effect on call-center employees' work stress	Acceptable
H1-3 "Scheduling time" shows a significant effect on call-center employees' work stress	Acceptable

Research hypothesis	Test results
H1-4 "Human downsizing" shows a significant effect on call-center employees' work stress	Inacceptable
H2 The Integrated scheduling shows a significant effect on call-center employees' job satisfaction:	Inacceptable
H2-1 "Fairness and efficiency" shows a significant effect on call-center employees' job satisfaction.	Acceptable
H2-2 "Negative effect" shows a significant effect on call-center employees' job satisfaction.	Acceptable
H2-3 "Scheduling time" shows a significant effect on call-center employees' job satisfaction.	Acceptable
H2-4 "Human downsizing" shows a significant effect on call-center employees' job satisfaction.	Inacceptable
H3 The call-center employees' work stress shows a significant effect on job satisfaction:	Acceptable
H3-1 "The stress of depression and fatigue" shows a significant effect on call-center employees' job satisfaction.	Acceptable
H3-2 "The stress of anxiety" shows a significant effect on call-center employees' job satisfaction.	Acceptable
H3-3 "Low self-esteem stress" shows a significant effect on call-center employees' job satisfaction.	Acceptable

Suggestions for practice

Based on the research results, this section will provide the following suggestions for call-center employees of one Telecom company.

(1) Establish good communication channel.
(2) Embody education and training, in order to achieve job satisfaction.
(3) The proper use of integrated scheduling.
(4) Strengthen employees' identification on organizational cohesion.

Suggestions for follow-up studies

The research mainly emphasizes call-center employees' work stress, job satisfaction. However, the other factors such as their work value, achievement motivation, emotional quotient and incentive system, etc. all might affect their job satisfaction. If subsequent researchers can include more influence factors, the research frame will be more comprehensive. In addition, the research did not further investigate the issue "job performance" or "After the introduction of integrated scheduling, how are customers'

satisfaction?", therefore the future researchers are advised to focus on these directions. Regarding the analysis suggestion of segmentation variable, the demographic variable could extend to job seniority or annual income variables.

REFERENCES

1. Canrinus, E.T., Helms-Lorenz, M., Beijaard, D., Buitink, J., and Hofman, A. (2012), "Self-efficacy, job satisfaction, motivation and commitment: Exploring the relationships between indicators of teachers' professional identity", *European Journal of Psychology of Education*, Vol. 27 No.1, pp. 115-132.

2. Cavaiola, A.A., Peters, C., and Hamdan, N. (2012), "Differentiation of self and its relation to work stress and work satisfaction", *Journal of Psychological Issues in Organizational Culture*, Vol. 3 No. 1, pp. 7-20.

3. Chen, G., Ployhart, R.E., Thomas, H.C., Anderson, N., and Bliese, P.D. (2011), "The power of momentum: A new model of dynamic relationships between job satisfaction change and turnover intentions", *Academy of Management Journal*, Vol. 54 No. 1, pp. 159-181.

4. Cooper, C.L., and Cartwright, S. (1997), "The psychological impact of merger and acquisition on the individual: A study of building society managers", *Human Relations*, Vo. 46 No. 3, pp. 327-342.

5. Gary-Stanley, J.A., and Muramatsu, N. (2011), "Work stress, burnout, and social and personal resources among direct care workers", *Research in Developmental Disabilities*, Vol. 32 No. 3, pp. 1065-1074.

6. Gyorkos, C., Becker, J., Massoudi, K., De Bruin, G.P., and Rossier, J. (2012), "The impact of personality and culture on the job demands-control model of job stress", *Swiss Journal of Psychology*, Vol. 71 No. 1, pp. 21-28.

7. Hoppock, R. (1935), *Job Satisfaction*, New York: Harper and Row.

8. Kahn, R.L., Wolfe, D.M., Quinn, R.P., and Sneek, J.D. (1964), *Organization Stress: Studies in Role Conflict and Ambiguity*, John Wiley & Sons, Inc.

9. Klassen, R.M., and Chiu, M.M. (2010), "Effects on teachers' self-efficacy and job satisfaction: Teacher gender, Years of experience, and Job stress", *Journal of Educational Psychology*, Vol. 102 No. 3, pp. 741-756.

10. Manocha, R., Black, D., Sarris, J., and Stough, C. (2011), "A randomized, controlled trial of meditation for work stress, anxiety and depressed mood in full-time workers", *Evidence-Based Complementary and Alternative Medicine*, Article ID 960583, 8 pages.

11. Mathieu, C., Neumann, C.S., Hare, R.D., and Babiak, P. (2013), "A dark side of leadership: Corporate psychopathy and its influence on employee well-being and job satisfaction", *Personality and Individual Differences*, Vol. 59 No. 3, pp. 83-88.

12. Meurs, J.A., and Perrewe, P.L. (2011), "Cognitive activation theory of stress: An integrative theoretical approach to work stress", *Journal of Management*, Vol. 37 No. 4, pp. 1043-1068.

13. Morris, M.G., and Venkatesh, V. (2010), "Job characteristics and job satisfaction: Understanding the role of enterprise resource planning system implementation", *MIS Quarterly*, Vol. 34 No. 1, pp. 143-161.

14. O'Neill, J.W., and Davis, K. (2011), "Work stress and well-being in the hotel industry", *International Journal of Hospitality Management*, Vol. 30 No. 2, pp. 385-390.

15. Patrick, H.A., and Sonia, J. (2012), "Job satisfaction and affective commitment", *The IUP Journal of Organizational Behavior*, Vol. 10 No. 1, pp. 23-36.

16. Robbins, S.P. (1989), *Organizational Behavior-Concepts, Controversies, and Applications*, Englewood Cliffs, New Jersey: Prentice Hall.

17. Rogelberg, S.G., Allen, J.A., Shanock, L., Scott, C., and Shuffler, M. (2010), "Employee satisfaction with meetings: A contemporary facet of job satisfaction", *Human Resource Management*, Vol. 49 No. 2, pp. 149-172.

18. Seley, H. (1956), *The Stress of Life*, New York: McGraw Hill.

19. Shultz, K.S., Wong, M., Crimmins, E.M., and Fisher, G.G. (2010), "Age differences in the demand-control model of work stress- An examination of data from 15 European countries", *Journal of Applied Gerontology*, Vol. 29 No.1, pp. 21-47.

20. Voltmer, E., Rosta, J., Seigrist, J., and Aasland, O.G. (2012), "Job stress and job satisfaction of physicians in private practice: comparison of German and Norwegian physicians", *International Archives of Occupational and Environmental Health*, Vol. 85 No. 7, pp. 819-828.

21. White, D.L., Froehle, C.M., and Klassen, K.J. (2011), "The effect of integrated scheduling and capacity policies on clinical efficiency", *Production and Operations Management*, Vol. 20 No. 3, pp. 442-455.

22. Xie, Z., Guo, Y., Liu, C., and Jing, Y. (2012), "Integrated scheduling algorithm of compacting operations on multi-equipment", *Advanced Science Letters*, Vol. 12 No. 1, pp. 423-427.

23. Xie, Z.Q., Yang, J., Teng, Y.Z., and Lan, L. (2011), "Integrated scheduling algorithm with setup time", *Advanced Materials Research*, Vol. 213 No. 2, pp. 226-230.

A SECURE SOFTWARE DEVELOPMENT FRAMEWORK BASED ON SECURITY PATTERNS

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ABSTRACT

Information security, a field of concepts and techniques for achieving security properties (e.g. confidentiality, integrity, and availability...etc.), is of great importance in the technology-advanced world. Furthermore, our critical dependence on highly distributed networking systems means that accurately assuring the security of such systems is really essential since the isolation is not possible (Lipson and Weinstock, 2008). Generally, the software is often designed and developed without security being in the mind of the developers (Viega and McGraw, 2001). As well known, malware infection continues to be the most commonly seen attack but few organizations establish and implement the secure System Development Life Cycle (SDLC) to protect their information assets (Martin and Rice, 2011). Therefore, software security should be further emphasized, and a formal development framework is necessary.

The production of a software system is usually conducted through the SDLC (Moore, 2008). However, in spite of adoption of well-planned SDLC process, many developed systems are still not free from security concerns. Hence, security concerns must be considered during every phase of software development, from requirement fetching, design, implementation, testing until deployment (Devanbu and Stubblebine, 2000).

From the perspective of software development, pattern or design pattern is a written document that describes a general solution for a frequently occurred problem. A problem and

its general solution are combined as a problem-solution pair and its common factors lead to patterns. Software designers can refer to these design patterns to find proper solutions for their systems.

Security patterns address security issues at widely varying levels of specificities ranging from architectural-level patterns involving the high-level design of system to the implementation-level patterns providing guidance on how to implement portions of functions or methods in the system. Many different classifications of them are developed in the existing studies, such as aspect types (creational, structural, or behavioral), abstraction level (network, host, or application) (Konrad et al., 2003), and function types. However, a standard procedure of using these security patterns seems still unavailable.

For easy understanding and convenient communication, patterns are designed with fixed formats that provide systematical information to adopters. According to Pattern-Oriented Software Architecture (Buschmann et al., 1996), the general pattern format is described in the following Table 1. Based on the security patterns, we have figured out the initial procedure of secure software development.

Table 1 Pattern Structure

Component	Description
Name	The name and a summary of the pattern.
Also Known As	The other names of the pattern.
Example	A real case demonstrating the problem and the need of the pattern.
Context	The situations in which the pattern may apply.
Problem	The problem the pattern addresses, including a discussion of its associated forces.
Solution	The fundamental solution principle underlying the pattern.
Structure	A detailed specification of the structural aspects of the pattern, using appropriate notations.
Dynamics	Typical scenarios describing the run-time behavior of the pattern.
Implementation	Guidelines for implementing the pattern.
Example Resolved	Discussion of any important aspects for resolving

Component	Description
	the example which are not yet covered in the Solution, Structure, Dynamics, and Implementation sections.
Variants	A brief description of variants or specializations of a pattern.
Known Uses	Examples of the use of the pattern, taken from existing systems.
Consequences	The benefits the pattern provides, and any potential liabilities.
See Also	References to patterns that solve similar problems.

Until now, we still continue improving this procedure. Moreover, the practical test is under preparation. That is, we will adopt this method to assist in the development of a software system at a case institute and then analyze the efficiency of this proposal. Moreover, we will also derive the managerial insight to enhance our contribution.

CONCLUSIONS

Software security is always a major issue for both the industrial and research communities during these years. Accompanying with the inevitable trend, a lot of potential threats may result in the financial or intangible loss of many software adopters. To effectively overcome this obstacle, the reasonable way is to apply specific patterns to software development architecture. Hence, this study is mainly aimed at proposing a process with security patterns to implement the well-structured software. These patterns enable the managers of software projects to incorporate the security concerns into the SDLC in order to raise the security level.

Keywords: Security Patterns, Software Security, Software Development Life Cycle

REFERENCES

1. Buschmann, F., Meunier, R., Rohnert, H., Sommerlad, P., and Stal, M. (1996). Pattern Oriented Software Architecture Volume 1: A System of Patterns. NJ: John Wiley & Sons.
2. Devanbu, P. T. and Stubblebine, S. (2000, May). Software engineering for security: a roadmap. In: Finkelstein, A. (Ed.), Proceedings of the Conference on the Future of Software Engineering, NY: ACM, 227-239.

3. Konrad, S., Cheng, B. H., Campbell, L. A., and Wassermann, R. (2003, March). Using security patterns to model and analyze security requirements. In: Bay, M. (Ed.), Proceedings of the 2nd International Workshop on Requirements Engineering for High Assurance Systems (RHAS '03), California: IEEE.

4. Lipson, H. and Weinstock, C. (2008). Evidence of assurance: Laying the foundation for a credible security case. Pennsylvania: Carnegie Mellon University.

5. Martin, N. and Rice, J. (2011). Cybercrime: Understanding and addressing the concerns of stakeholders. Computers & Security, 30(8), 803-814.

6. Moore, J. W. (2008) ISO 12207:2008. Systems and software engineering - Software life cycle processes. Geneva: International Organization for Standardization

7. Viega, J. and McGraw, G. (2001). Building Secure Software: How to Avoid Security Problems the Right Way. Boston: Addison-Wesley.

JOURNAL EVALUATION BASED ON INTEGRATING SUBJECTIVE AND OBJECTIVE INFORMATION

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ABSTRACT

In order to evaluate the quality of open access journals, this paper proposes a subjective and objective attribute value integrating evaluation approach. According to the respective characteristics of the different subjective attributes, the appropriate linguistic evaluation sets are designed for assessing the journals. The basic linguistic evaluation set is designed, based on which various linguistic evaluation terms from different sets are all transformed into the fuzzy sets over it. Thus, various linguistic evaluation terms with different granularities are comparable, and ready for further integration. With respect to the objective attributes, after normalizing their attribute values, fuzzy operations are conducted to transform them into the fuzzy sets over the basic linguistic evaluation set. Thus, the subjective and objective attribute values are all transformed into the same format and can be integrated for calculating the overall values of the journals. Finally, an example is used for illustrating the proposed approach.

Key Words: Open access journals; Subjective attributes; Objective attributes; Integrating evaluation; Linguistic evaluation; Ranking

INTRODUCTION

Open access journals are playing increasingly important roles as the new bridge for knowledge dissemination. Compared with the traditional journals, the open access journals show some new features, such as link indicator (number of links by other papers) that is unique in the network environment, and downloads[1]. Especially some specific aspects appear on the network, such as, the user effect, Web site interaction (stability, ease of use and security) and network marketing [2]. In [3], communication quality of the open access journals is considered the unique and important feature that is different from the paper journals.

It is noticed that these new features present the unique properties of the open access journals, and some of them need to invite experts to give subjective evaluations [4]. In

addition, the specific meaning and characteristics of these features can only be accurately and fully reflected by linguistic terms given by the experts [5, 6]. In this paper, the evaluation on the quality of the open access journals is considered as a multiple attributes decision making problem with the subjective attributes and the objective attributes. However, the research on evaluating the quality of the open access journals with the subjective attributes and the objective attributes falls behind. There is rare research on quantifying the evaluation information against the subjective attributes. In [3], the linguistic term set {"better", "good", "fair", "poor", "worse"} is used for evaluating the stability of web site, while the linguistic term set with "have" and "none" is used for evaluating the individuation attribute. However, there is no approach that is proposed to aggregate the various linguistic terms with different granularity.

On one hand, different linguistic term sets are used for different subjective attributes and they are not comparable. So, it is necessary to aggregate different linguistic terms from different sets to obtain the overall evaluation against the subjective attributes. On the other hand, in [7] it is suggested that some objective and quantitative attributes should be considered as well as the subjective ones when evaluating the open access journals. In addition, different objective attributes are often of different dimensions and are not comparable directly, which need normalization process to convert them into comparable data [8,9]. Furthermore, how to integrate the subjective linguistic evaluation information with the objective evaluation information is still an urgent problem to be solved.

With respect to the subjective linguistic information and the objective information in evaluating the open access journals, this paper presents a multiple attribute decision making integration approach. The organization of this paper is as follows: section two describes the problem focused. Section three proposes the approach to integrating the subjective linguistic evaluation information with the objective evaluation information so that the overall values for the open access journals would be obtained. Section four gives an illustration example, and section five summarizes the whole paper.

PROBLEM DESCRIPTIONS AND LINGUISTIC EVALUATION

Problem Descriptions

In order to facilitate formulating the problem discussed above, the following symbols are used to describe the problem of evaluating the open access journals with subjective and objective attributes.

$S=\{S_1, S_2, \ldots S_m\}$ is the set of alternatives, i.e, the open access journals, $m \geq 2$.

$C=\{C_1, C_2, \ldots C_n\}$ is the set of attributes, $n \geq 2$. As discussed above, the attributes for evaluating the open access journals are classified into two categories: the subjective attributes and objective attributes.

$W = (w_1, w_2, \ldots, w_n)$ is the weight vector, where w_j is the weight of attributes, $0 \leq w_j \leq 1$, and $\sum_{j=1}^{n} w_j = 1$.

$\widetilde{A} = [\widetilde{a}_{ij}]_{m \times n}$ is the hybrid decision matrix with linguistic evaluation values against the subjective attributes and the numeric values against the objective attributes. Where $\widetilde{a}_{ij}$ denotes the attributes values on alternative S_i against attribute C_j, $i = 1,\ldots,m$, $j = 1,\ldots,n$. The linguistic evaluation for different subjective attributes may be of different granularities, and the numeric values against the objective attributes may be of different dimensions, therefore, the hybrid decision matrix $\widetilde{A} = [\widetilde{a}_{ij}]_{m \times n}$ should be normalized.

Concepts of linguistic evaluations

Linguistic terms

In complex or uncertain decision environment, linguistic terms can be used to express decision makers' subjective opinions or judgments more precisely [5].

Proceedings of 2014 International Conference on
Technology Innovation and Industrial Management
28th-30th May 2014, Seoul, South Korea

Definition 1 A linguistic term $\widetilde{T}$ on real number set is defined as a triangular fuzzy number (denoted as (u, α, β)), if its membership function $\mu_{\widetilde{T}}$ ($R^{+} \to [0, 1]$) is defined as,

$$\mu_{\widetilde{T}}(x) = \begin{cases} \dfrac{x-\alpha}{u-\alpha}, & x \in [\alpha, u], \\[2ex] \dfrac{x-\beta}{u-\beta}, & x \in [u, \beta], \\[2ex] 0, & other \end{cases} \tag{1}$$

where, $\alpha \le u \le \beta$, and u is the model value, α and β stand for the lower value and the upper value of linguistic term $\widetilde{T}$ respectively.

Linguistic term set

When alternatives are evaluated against the subjective attributes, the linguistic term sets for the subjective attributes should be determined firstly. Different linguistic term sets are employed for different subjective attributes.

Suppose *TERMSET*=$\{t_0, t_1, \ldots, t_g\}$ is a linguistic term set for evaluating the alternatives against a subjective attribute. *TERMSET* is defined as the ordering set, which is composed of a number of linguistic terms with odd number (i.e., $g+1$ is odd number). For example, consider a set of seven terms, i.e., *TERMSET* =$\{t_0$="none", t_1="very poor", t_2="poor", t_3="fair", t_4="good", t_5="very good", t_6="perfect"$\}$. The following properties of *TERMSET* are assumed[10]: (1) The *TERMSET* is ordered: $t_i \ge t_j$, if $i \ge j$. The symbol "$\ge$" denotes "better or equal"; (2) There is the negation operator "*Neg*": Neg(t_i)=t_j, such that $j=g-i$, where $g+1$ is the number of elements in *TERMSET*, and the largest term in *TERMSET* is t_g; (3) There is the max operator and the min operator: Max$\{t_i, t_j\}=t_i$ and Min$\{t_i, t_j\}=t_j$ if $t_i \ge t_j$.

Basic linguistic evaluation set

In the hybrid decision matrix $\widetilde{A} = [\widetilde{a}_{ij}]_{m \times n}$, the linguistic evaluation on the alternative against different subjective attributes are of different granularities (i.e., come from different linguistic evaluation sets), and are not comparable. Therefore they should be uniformed. In this study, term set {C, B-, B, B+, A-, A, A+} is adopted as the basic grade set (i.e., basic linguistic evaluation set), based on which the linguistic attribute values are uniformed as the fuzzy set over it. In order to facilitate description, *TERMSET*^{B}=$\{ term_0^B, term_1^B, \ldots, term_g^B\}$ is used as the basic linguistic evaluation set. *TERMSET*^{B} is of the properties as discussed in

Linguistic term set

Two - tuple linguistic [10]

Definition 2   Given a linguistic evaluation set *TERMSET*（*TERMSET*={t_0, t_1, …, t_g}）, a tuple (t_k, λ_k) is called the **T**wo - tuple linguistic on *TERMSET* if λ_k is the symbolic translation from term t_k, and $\lambda_k \in [-0.5, 0.5]$, $k = 1, …, g$.

Usually, the result of a symbolic aggregation operation based on the *TERMSET*, for instance ω, can be expressed as a **T**wo - tuple linguistic on the *TERMSET*, i.e.,

$$\omega \rightarrow t_k \times [-0.5, 0.5) \tag{2}$$

Where the Two - tuple linguistic in （2）can be calculated by Definition 3.

Definition 3 Let real number $\omega \in [0, g]$ be the result of an aggregation of the indexes on *TERMSET*（*TERMSET*={t_0, t_1, …, t_g}）, where $g + 1$ is the cardinality of *TERMSET*, then the Two-tuple that expresses the equivalent information to ω is obtained with the following function Δ[10]:

$$\Delta: [0, g] \rightarrow TERMSET \times [0.5, 0.5] \tag{3}$$

i.e.,

$$\Delta(\omega) = \begin{cases} t_k & k = round(\omega) \\ \lambda_k = \omega - k & \lambda_k \in [-0.5, 0.5] \end{cases} \tag{4}$$

where "round" is the usual round operation.

Definition 4 Given a tuple (t_k, λ_k) on the linguistic evaluation set *TERMSET*（*TERMSET*={t_0, t_1, …, t_g}）, where t_k is the *k th* element in *TERMSET*, and $\lambda_k \in [-0.5, 0.5]$, then there is an inverse function Δ^{-1}, which transforms (t_k, λ_k) into a corresponding number ω [10]($\varpi \in [0, g]$),

$$\Delta^-: TERMSET \times [0.5, 0.5] \rightarrow [0, g] \tag{5}$$

i.e.,

$$\Delta^- (t_k, \lambda_k) = k + \lambda_k = \omega \tag{6}$$

THE PROPOSED APPROACH

Normalize the Hybrid Decision Matrix

Normalize the linguistic evaluation against the subjective attributes

Since different linguistic term sets are used for evaluating the alternatives against the subjective attributes, normalization must be conducted to transform the linguistic evaluation with different granularities into the fuzzy set over $TERMSET^{B[11]}$.

The linguistic term $term_l^B$ in the basic linguistic evaluation set $TERMSET^B = \{ term_0^B$, $term_1^B, \ldots, term_g^B \}$ is expressed as a triangular fuzzy number (u_l^B, α_l^B, β_l^B), $l=0,\ldots, g$.

Suppose $TERMSET^j(g_j+1$ is its the cardinality) is the linguistic evaluation set corresponding to subjective attribute C_j, for the linguistic evaluation value $term_i^j$ of alternative S_i, $term_i^j \in TERMSET^j$, $i=1,\ldots,m, j=1,\ldots,n,$ the following function τ can be used to transform $term_i^j$ into the fuzzy set over $TERMSET^{B\,[10]}$,

$$\tau : term_i^j \rightarrow F_i^j (TERMSET^B) \tag{7}$$

Where，$F_i^j (TERMSET^B)$ is the fuzzy set over $TERMSET^B$, and

$$F_i^j (TERMSET^B) = \{(term_0^B , \gamma_0^{ij}),(term_1^B , \gamma_1^{ij}),\ldots,(term_g^B , \gamma_g^{ij})\} \tag{8}$$

and,

$$\gamma_l^{ij} = \max_x \min \{\mu(term_i^j), \mu_l(term_l^B)\}, \qquad l=0，1,\ldots,g \tag{9}$$

Where, $\mu (\cdot)$ and $\mu_l (\cdot)$ are the membership functions of term $term_i^j$ and $term_l^B$ respectively.

Thus, in the hybrid decision matrix $\widetilde{A} = [\widetilde{a}_{ij}]_{m \times n}$, with multiple granularities, the subjective attribute values $\widetilde{a}_{ij}$（i.e., $term_i^j$）with multiple granularities, are all transformed into the fuzzy set over $TERMSET^B$, denoted as $F_i^j (TERMSET^B)$.

Normalize the numeric evaluation against the objective attributes

a) Make the numeric evaluation dimentionless

The following formulas are employed in this paper to Make the numeric evaluation against the objective attributes dimentionless[8, 9],

$$b_{ij} = \frac{a_{ij} - a_j^{\min}}{a_j^{\max} - a_j^{\min}}, \quad i=1,...,m, \quad j=1,...,n, \quad \text{for the benefit attributes (10)}$$

$$b_{ij} = \frac{a_j^{\max} - a_{ij}}{a_j^{\max} - a_j^{\min}}, \quad i=1,...,m, \quad j=1,...,n, \quad \text{for the cost attributes} \quad (11)$$

Where, $a_j^{\max}$ and $a_j^{\min}$ are given as bellows:

$$a_j^{\max} = \max\{a_{1j}, a_{2j},..., a_{mj}\}, \qquad j=1,...,n \qquad (12)$$

$$a_j^{\min} = \min\{a_{1j}, a_{2j},..., a_{mj}\}, \qquad j=1,...,n \qquad (13)$$

b) Transform the normalized numeric evaluation into the fuzzy set over $TERMSET^B$

Given the basic linguistic evaluation set $TERMSET^B$ ($TERMSET^B = \{term_0^B, term_1^B, ...,$ $term_g^B\}$), the numeric evaluation b_{ij} in (10) or (11) can be transformed into the fuzzy set over $TERMSET^B$, while the membership function for $term_l^B$ is stated as follows:

$$\gamma_k^{ij} = \tau(b_{ij}) = \begin{cases} 0 & b_{ij} \notin [\alpha_k^B, \beta_k^B] \\ \dfrac{b_{ij} - u_k^B}{u_k^B - \alpha_k^B} & b_{ij} \in [\alpha_k^B, u_k^B] \\ \dfrac{b_{ij} - u_k^B}{u_k^B - \beta_k^B} & b_{ij} \in [u_k^B, \beta_k^B] \end{cases}, \quad i=1,...,m, j=1,...,n, k=0,..., g \quad (14)$$

Thus, the normalized numeric evaluation against the objective attributes is transformed into the fuzzy set over $TERMSET^B$, i.e., $\{(term_0^B, \gamma_0^{ij}),(term_1^B, \gamma_1^{ij}),...,(term_g^B, \gamma_g^{ij})\}$, which is denoted as $F_i^j(TERMSET^B)$, where γ_k^{ij} is calculated in (14), $k=0,..., g$.

Based on the discussions in 3.1.1 and 3.1.2, the hybrid decision matrix $\tilde{A} = [\tilde{a}_{ij}]_{m \times n}$ is transformed into the fuzzy set over $TERMSET^B$, denoted as $\tilde{F} = [F_i^j(TERMSET^B)]_{m \times n}$.

Calculate the overall values of alternatives

Based on the discussions in 3.1, the hybrid decision matrix $\widetilde{A}^k = [\widetilde{a}_{ij}^k]_{m \times n_1}$ is normalized into the fuzzy set over $TERMSET^B$, $\widetilde{F} = [F_i^j(TERMSET^B)]_{m \times n}$, the overall values of alternatives can be calculated as follows:

$$Overall_i = \sum_{j=1}^n F_i^j(TERMSET^B)w_j, \qquad i = 1,...,m \qquad (15)$$

Where w_j is the weight of attribute C_j, which can be given by the decision maker, $j=1,\ldots,$ n.

Rank the alternatives

It is obvious that the overall values $Overall_i$ of alternative S_i obtained in 3.2 is still the fuzzy set over $TERMSET^B$, $i = 1,...,m$, which is denoted as follows:

$$Overall_i = \{(term_0^B, o_0^i), (term_1^B, o_1^i),...,(term_g^B, o_g^i)\}, \quad i = 1,...,m \quad (16)$$

Therefore, the single-point overall value d_i of alternative S_i is obtained,

$$d_i = \frac{\sum_{k=0}^g k o_k^i}{\sum_{k=0}^g o_k^i}, \qquad i = ,.1m \qquad (17)$$

The alternatives can be ranked descendingly according to the values of $\widetilde{d}_i$ and assigned grades respectively.

It should be noted that if alternative S_i ($i = 1,...,m$) needs to be assigned a linguistic evaluation, for example, a grade, then, based on Definition 3, the single-point overall value d_i in (17) can be transformed into a Two - tuple on $TERMSETB^{[11]}$. In addition, the comparison between Two – tuples (t_k, λ_k) and (t_l, λ_l) can be conducted by following rules:

(1) If $k < l$, then $(t_k, \lambda_k) < (t_l, \lambda_l)$;
(2) If $k = l$, ① when $\lambda_k = \lambda_l$, then $(t_k, \lambda_k) = (t_l, \lambda_l)$; ② When $\lambda_k < \lambda_l$, then $(t_k, \lambda_k) < (t_l, \lambda_l)$;
③ when $\lambda_k > \lambda_l$, then $(t_k, \lambda_k) > (t_l, \lambda_l)$.

ILLUSTRATION

In this paper, fourteen open access journals are evaluated. The journals are: Computer Engineering and Applications, Computer Engineering, Food Science, Application Research of Computers, Journal of Computer Applications, Rock Mechanics and Engineering Journal, Journal of Electronic, Journal of Chemical, Automation of Electric Power Systems, Systems Engineering Theory and Practice, Chinese Journal of Scientific Instrument, Journal of Systems Engineering and Electronics, Chinese Journal of Electrical Engineering and China Mechanical Engineering, denoted as alternatives S_1, S_2, ..., S_{14}, respectively.

The objective attributes are downloads, No. of Views, No. of papers, online journal database usage ratio (DR), web page rank value (PR), online journal Impact factor (IF) and comprehensive quantitative indicators (Net_IF). The evaluation information against these objective attributes is showed in Table 1[12]

Table 1. The evaluation information of alternatives against the objective attributes[12]

Journal name	Downloads	No. of Views	No. of papers	DR	PR	IF	Net_IF
Computer Engineering and Applications	66626	302359	12332	1.191	0.3	0.267	0.503
Journal of Computer Engineering	54044	223234	9725	1.345	0.3	0.239	0.525
Food Science	31035	152304	4473	1.414	0.2	0.44	0.648
Application Research of Computers	30949	134215	5097	1.4	0.4	0.342	0.615
Journal of Computer Applications	27375	111269	5016	1.343	0.4	0.361	0.612
Rock Mechanics and Engineering Journal	22954	119404	4132	1.068	0.4	0.693	0.743
Journal of Electronic	22843	112510	3887	1.193	0.4	0.548	0.687
Journal of Chemical	21453	114547	4095	0.981	0.4	0.787	0.777
Automation of Electric Power Systems	21294	119232	3437	1.106	0.4	1.119	1.008
Systems Engineering Theory and Practice	20626	105826	2120	1.896	0.5	0.662	0.946
Chinese Journal of	20528	74084	4307	1.321	0.2	0.568	0.701

Journal name	Downloads	No. of Views	No. of papers	DR	PR	IF	Net_IF
Scientific Instrument Journal of Systems Engineering and Electronics	19782	90890	3543	1.215	0.2	0.343	0.539
Chinese Journal of Electrical Engineering	19627	99142	2919	1.311	0.3	2.437	1.834
China Mechanical Engineering	18143	97907	3870	0.869	0.3	0.39	0.496

The subjective attributes are interactivity(C_1), stability (C_2), security (C_3) and ease of use (C_4). With respect to interactivity, {"worse", "bad", "fair", "good", "better" } is used for evaluation; With respect to stability, {"worse", "bad", "fair", "good", "better" } is used for evaluation; With respect to security, {"lowest", "lower", "low", "fair", "high", "higher", "highest"} is used for evaluation; With respect to ease of use, { "bad", "fair", "good"} is used for evaluation. An expert is invited to give his evaluations against the subjective attributes, as showed in Table 2.

Table 2. The evaluation information of alternatives against the subjective attributes

Journal name	Interactivity	Stability	Security	Ease of use
Computer Engineering and Applications	fair	good	high	Fair
Journal of Computer Engineering	good	fair	fair	Fair
Food Science	good	fair	fair	Fair
Application Research of Computers	good	fair	higher	good
Journal of Computer Applications	fair	fair	fair	Fair
Rock Mechanics and Engineering Journal	good	fair	high	Fair
Journal of Electronic	fair	fair	high	Fair
Journal of Chemical	fair	fair	fair	Bad
Automation of Electric Power Systems	fair	fair	fair	Fair

Journal name	Interactivity	Stability	Security	Ease of use
Systems Engineering Theory and Practice	fair	fair	higher	Fair
Chinese Journal of Scientific Instrument	good	fair	fair	Fair
Journal of Systems Engineering and Electronics	good	good	high	fair
Chinese Journal of Electrical Engineering	good	fair	fair	fair
China Mechanical Engineering	fair	fair	fair	fair

Based on the approach proposed in this paper, the evaluation information of the alternatives against the subjective and objective attributes is normalized respectively, and integrated (attribute weights are given). The final results of the overall values of the alternatives are in the format of fuzzy set over the basic linguistic evaluation set $TERMSET^B$. Due to the limit of space, the calculation processes are not presented, and the results are showed in Table 3, i.e., overall values of alternatives in the format of fuzzy set (membership values o_l^i) and single-point, Two-tuple. Therefore, according to Table3, the rankings of the alternatives is : S_1> S_4> S_{10}> S_{13}> S_2> S_5> S_6> S_3> S_7> S_{12}> S_{11}> S_9> S_{14}> S_8. The Two-tuples of the overall values of the alternatives is showed in the right column in Table 3, for instance, the Two-tuple of the overall value of Computer Engineering and Applications is ($term_3^B$,0.2676), i.e., (B+，0.2676).

Table 3. Overall values of alternatives in the form of fuzzy set (membership values o_l^i) and single-point, Two-tuples

Alternatives	$term_0^B$	$term_1^B$	$term_2^B$	$term_3^B$	$term_4^B$	$term_5^B$	$term_6^B$	single-point	Two-tuple
S_1	0.1974	0.0794	0.2985	0.2181	0.2863	0.1363	0.2954	3.2676	($term_3^B$,0.2676)
S_2	0.1927	0.0753	0.2267	0.3943	0.3752	0.2191	0.0227	2.9510	($term_3^B$,-0.049)
S_3	0.1838	0.2681	0.2974	0.3807	0.2199	0.1363	0.0227	2.4536	($term_2^B$,0.4536)

Alternatives	$term_0^B$	$term_1^B$	$term_2^B$	$term_3^B$	$term_4^B$	$term_5^B$	$term_6^B$	single-point	Two-tuple
S_4	0.1079	0.2033	0.2159	0.2242	0.2802	0.25	0.0909	3.0777	$(term_3^B, 0.0777)$
S_5	0.0687	0.3227	0.2680	0.5012	0.2981	0.0818	0.0227	2.6228	$(term_3^B, -0.3772)$
S_6	0.0596	0.4896	0.2052	0.2183	0.3770	0.1363	0.0416	2.6146	$(term_3^B, -0.3854)$
S_7	0.0917	0.4682	0.2672	0.2729	0.3588	0.0818	0.0227	2.4318	$(term_2^B, 0.4318)$
S_8	0.1746	0.4776	0.2431	0.2956	0.1997	0.0363	0	1.9839	$(term_2^B, -0.0161)$
S_9	0.1672	0.3367	0.3278	0.3593	0.1997	0.0363	0	2.1377	$(term_2^B, 0.1377)$
S_{10}	0.1288	0.2344	0.2803	0.3589	0.1838	0.1727	0.2045	3.0046	$(term_3^B, 0.0046)$
S_{11}	0.2856	0.3202	0.1747	0.3738	0.1954	0.1363	0.0227	2.2471	$(term_2^B, 0.2471)$
S_{12}	0.3906	0.223	0.1520	0.1707	0.3045	0.1909	0.0227	2.3018	$(term_2^B, 0.3018)$
S_{13}	0.1765	0.1825	0.2452	0.3684	0.1954	0.1363	0.2045	2.9614	$(term_3^B, -0.0386)$
S_{14}	0.3831	0.2644	0.2705	0.3636	0.1772	0.0818	0.0227	2.0150	$(term_2^B, 0.0150)$

SUMMARY

In order to overcome the shortcomings of the evaluation methods for the quality of the open access journals, this paper proposes an approach to integrating the subjective and objective evaluation information. With respect to the subjective attributes, their corresponding linguistic evaluation sets are designed. Based on the basic linguistic evaluation set, various linguistic evaluation terms for the subjective attributes are all uniformed into the fuzzy sets over it. The evaluation information of the alternatives against the objective attributes are also normalized into the fuzzy sets over the basic linguistic evaluation set, so that it is comparable with that against the subjective attributes. In the end, the overall values of the alternatives can be obtained by be integrating both types of information, as well as their rankings and Two-tuples.

Proceedings of 2014 International Conference on
Technology Innovation and Industrial Management
28th-30th May 2014, Seoul, South Korea

The proposed approach can integrate the subjective and objective evaluation information for the open access journals effectively, and is of general applicability, which is suitable in many applications such as society, engineering and economy. Furthermore, the proposed approach is readily implemented into a computer-based information system to facilitate the whole process in evaluating the quality of the open access journals.

ACKNOWLEDGEMENT

REFERENCE

1. Dang Y.R., Wang L.Y., Gao F., Li K., Huang Y., He F. L., Changes and Development of Key Indicators in Journal Citation Reports on Web, Chinese Journal of Scientific and Technical Periodicals, 2007, 18(6): 951-956.
2. Xie X.Z., Wang M., Ke X.N., Development of Network Journals and Its Evaluation, PUBLISHING JOURNAL, 2009, 17(1):22-28.
3. Zhang B., Xing Y. Comparative Analysis of the pure electronic journals at home and abroad, Journal of Library Science, 2011, 33(1):133-136.
4. Cui G.P., Development Tendency of Electronic Journal-only-on-net, Journal of Xi'an University of Arts and Science (Natural Science Edition), 2007, 10(2):121-124.
5. Zadeh L A. A computational approach to fuzzy quantifiers in natural languages, Computing Mathematics Applications, 1983, 9: 149-184.
6. Herrera F., Herrera-Viedma E., "Linguistic decision analysis: steps for solving decision problems under linguistic information," Fuzzy Sets and Systems, 2000, 115 (1): 67-82.
7. Feng B.Y., Quality Evaluation on the pure electronic Journals, Science Information Development & Economy, 2009, 19(10): 69-71.
8. Qiu J.P., Zhang R., Zhao R.Y., Journal Evaluation Index System and Quantitative Method Research, Modern Library and Information Technology, 2004, 7: 23-26.
9. Lin C.Y. Mo L., Attribute mathematics overall evaluation model of journal quality system in nature science, Mathematics in Practice and Theory, 2004, 34(5): 1-7.
10. Xu Z S. Uncertain linguistic aggregation operators based approach to multiple attribute group decision making under uncertain linguistic environment [J]. Information Sciences, 2004, 168（1-4）: 171-184.

11. Herrera F., Martinez L., Sanchez P.J. Managing non-homogeneous information in group decision making[J]. European Journal of Operational Research, 2005, 166: 115-132.

12. Yan H. B., Bian F.Q., Evaluation on network journals, Chinese Journal of Science and Technical Periodical, 2008, 19 (6) : 977-981.

APPLYING INTUITIONISTIC FUZZY SEASONALITY FORECASTING
FOR INDUSTRY SALES FORECASTING PROBLEM

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ABSTRACT

Purpose : *The purpose of this paper is to present the development of a novel intuitionistic fuzzy seasonality regression (IFSR) with particle swarm optimization (PSO) algorithms to accurately forecast industry sales for printing and writing paper, which are typical seasonal time-series data.*

Design/methodology/approach : *In this paper, the authors develop the intuitionistic fuzzy linear regression (IFLR) with spreads unrestricted to correctly approach the trend of seasonal time-series data when the decomposition method is used. Furthermore, PSO algorithms were simultaneously employed to select the parameters of the IFSR model.*

Findings : *First, the fuzzy seasonality index, which can interpret the uncertainty of data, thereby enhancing the ability of the IFSR with PSO model to capture seasonal time series data patterns. Second, the IFSR with PSO model, which is based on a proposed IFLR with spreads unrestricted, can efficiently capture the trends of data. Third, the PSO can effectively improve the performance of the proposed IFSR.*

Practical implications : *Seasonal time series prediction is a critical topic and certain time series data contain uncertain or unpredictable factors. To handle such seasonal factors and uncertain forecasting seasonal time-series data, the proposed IFSR with PSO method effectively extends the intuitionistic fuzzy linear regression (IFLR).*

Originality/value : *This study is the first attempt to use an IFLR method with spreads unrestricted and a fuzzy seasonality index to forecast seasonal time series data. The empirical*

results of the proposed IFSR with PSO model revealed improved performance regarding forecasting accuracy, compared with the other methods. Therefore, the proposed IFSR with PSO model can efficiently provide credible values of prediction for seasonal time-series data in uncertain environments.

INTRODUCTION

The seasonal time series is a sequence of seasonal data points recorded sequentially in time. Over the past several decades, many studies have been devoted to developing and improving seasonal time series forecasting models, and seasonal time series prediction has been widely investigated and used in many fields. One of the most popular and best-known approaches is the seasonal auto regressive integrated moving average (SARIMA) model 1. The SARIMA model has been successfully used in many fields of forecasting, such as soil dryness index 2, tourism demand 4, and municipal solid waste management 5. In recent years, the artificial neural network (ANN) model has provided an alternative for forecasting seasonal data patterns 6. The literature 711 indicates that ANN can obtain desirable results in seasonal and trend forecasting. However, although this model has the advantage of accurate forecasting in short periods, it also has several limitations. First, it assumes that the future values of a time series have a clear and definite functional relationship with current values, past values, and white noise. Second, at least 50 and preferably 100 observations or more are required 12. Finally, although the foregoing results are promising, certain time series data contain uncertain or unpredictable factors. Therefore, this study employs fuzzy regression (FR) 13 technology to handle unpredictable factors or uncertainties in seasonal time series data.

Fuzzy regression (FR)is a methodology based on the fuzzy set theory, which concerns the possibility distribution for an imprecise or vague phenomenon and can be expressed by yielding fuzzy parameters/coefficients. FR can represent data accrual without losing the original meaning of the data, and can analyze both the trends of variability and the mean of the data. Kim et al. 14 noted that classical regression analysis uses rigid assumptions about statistical properties. FR may relax these rigid assumptions regarding properties such as the normality of error terms and predictions, and random measurement errors in recorded observations. When this approach is used, observational uncertainties or fuzziness are represented by the fuzzy parameters related to the indefinite structure of the system. The objective function then minimizes the total fuzziness of the estimated outputs yielded based on the condition that an *H*-level-set inclusion of all observed data holds 13. Increasing the *H*-factor expands the confidence interval and thus increases the probability that out-of-sample values will fall within the model description. This is comparable to increasing the confidence in a statistical regression model by increasing the confidence interval. A number of investigations have proposed different FR methods 15–28. Chang and Lee 17 proposed a concept of FR analysis that allows for the possibility that spreads

of the fuzzy parameters can be unrestricted parameters. This overcomes the problem that both trends of modes and spreads of FR may be inconsistent and conflicting and, if not treated properly, may predict incorrect trends. The unrestricted fuzzy regression may correct the trends of the predicted model. Chang 29 applied FR to a fuzzy forecasting technique for the seasonality of time-series data. The fuzzy forecasting technique can analyze both the seasonal fuzziness and the model trends. Paravathi et al. 30 proposed an intuitionistic fuzzy linear regression (IFLR), with which they attempted to minimize the total fuzziness of the model, which is related to the width of the IFS coefficient. These previous studies successfully extended the fuzzy linear regression of Tanaka et al. 13. They revealed flaws in traditional FR and, as a result, successfully modified or extended traditional FR.

Based on the views expressed in previous research, which includes studies on unrestricted FR, fuzzy seasonality forecasting, and intuitionistic FR models, the IFLR method should be extended to include the seasonality of time-series data. Therefore, this study develops an intuitionistic fuzzy seasonality regression (IFSR) model that exploits the unique strength of decomposition techniques and intuitionistic fuzzy regression to forecast industry sales for printing and writing paper. In addition, to obtain the correct trend, intuitionistic FR with unrestricted spreads has also been developed. Furthermore, the parameters of traditional FR are typically provided by expert knowledge, which may be less easy to obtain in different cases. In this study, particle swarm optimization (PSO) was employed to identify the optimal performance of the proposed IFSR, which can obtain optimal parameters of the proposed IFSR model. Section 2 introduces IFLR with spreads unrestricted. Section 3 presents the IFSR with PSO. In Section 4, an industry sales forecasting problem is used to demonstrate performances of various forecasting models. Finally, Section 5 concludes the study

INTUITIONISTIC FUZZY LINEAR REGRESSION WITH SPREADS UNRESTRICTED

Based on IFLR and the views of Chang and Lee 17, this study presents the development of an intuitionistic FR with spreads unrestricted. The spreads unrestricted can precisely represent the different trends of fuzzy data in IFRL model, particularly in the opposite trend. Following Section 2.1, this study introduces the basic definition and concept of the fuzzy set and intuitionistic fuzzy set, FLR with spreads unrestricted 17, and intuitionistic FR with spreads unrestricted.

Basic definition of fuzzy set and intuitionistic fuzzy set

Fuzzy set was first introduced by Zadeh 31. A membership function can be defined for all the elements a in a referential set U. A fuzzy set (A) can be defined by the membership function $\mu_A(a)$, which takes values in [0, 1]. Thus, a fuzzy set (A) is said to be convex if all the ordinary subsets of A are convex. A fuzzy set is to be normalized if $\exists a \in U, \mu_A(a) = 1$. For an *interval* or

level of confidence or termed *α-cut* or *α-level set* at level $\alpha \in (0, 1]$, an ordinary subset of A can be defined and denoted as $[A]_{\alpha}$,

$$[A]_{\alpha} = \left\{ a \in U \,\middle|\, \mu_A(a) \geq \alpha \right\}, \ \alpha \in (0, 1]. \tag{1}$$

Moreover, a fuzzy number (FN) can be defined as a convex normalized fuzzy set on a real line $\Re$ consisting of an upper semi-continuous membership function and bounded support. Dubois and Prade 32 defined a general representation for FNs, which can be called the *L-R* type representation. In this study, this representation is also called the bound form representation.

Definition 1 (Bound form representation of FNs) Specifically, a *symmetrical FN* may be written as $A = (\psi, c)_{LR}$, where $\psi - c$ and $\psi + c$ represent the *lower* and *upper bounds*, ψ the *mode*, *mean*, or *center value*, and *L*, *R* the left and right reference (or shape) functions, respectively, of A. ($\psi - c$, $\psi + c$) is the *support* of A. In the case, A has the membership function

$$\mu_A(a) = \begin{cases} 1 - |\psi - a| / c, & \psi - c \leq a \leq \psi + c, \\ 0, & \textit{otherwise}. \end{cases} \tag{2}$$

However, the degree of non-membership of an element to a fuzzy set may not be equal to 1 minus the degree of membership; there may be a hesitation degree. Therefore, as a generalization of fuzzy sets, IFSs were introduced by Atanassov 33. Burillo and Bustince 34 showed that vague sets (VS) are a type of IFS. The IFSs were proposed as an extension of fuzzy sets. The basic definition can be described as following 33:

Definition 2 (Intuitionistic fuzzy set) 33 An intuitionistic fuzzy set (IFS) A in X is defined as an object of the form $A = \{<x, \mu_A(x), \nu_A(x)>: x \in X\}$, where the function $\mu_A(x): X \to [0, 1]$ and $\nu_A(x): X \to [0, 1]$ define the degree of membership and the degree of non-membership of the element $x \in X$ respectively, and for every $x \in X$ in A, $0 \leq \mu_A(x) + \nu_A(x) \leq 1$.

Definition 3 (Triangular intuitionistic *symmetrical FN*) 35 A triangular intuitionistic *symmetrical FN* A^I is an IFS in $\Re$ consisting of membership and non-membership functions as follows:

$$\mu_{A^I}(a) = \begin{cases} (a - (\psi - c)) / c, & \textit{for } a \in [\psi - c, \psi], \\ ((\psi + c) - a) / c, & \textit{for } a \in [\psi, \psi + c], \\ 0 & \textit{otherwise}. \end{cases} \tag{3}$$

and

$$v_{A^I}(a) = \begin{cases} (\psi - a)/c', & for \ a \in [\psi - c', \psi], \\ (a - \psi)/c', & for \ a \in [\psi, \psi + c'], \\ 1 & otherwise. \end{cases} \qquad (4)$$

where $\psi \in \Re$, c, $c' \geq 0$ such that $c \leq c'$. Here c and c' are the spreads of membership and non- membership, respectively. Fig. 1 shows the triangular intuitionistic symmetrical FN.
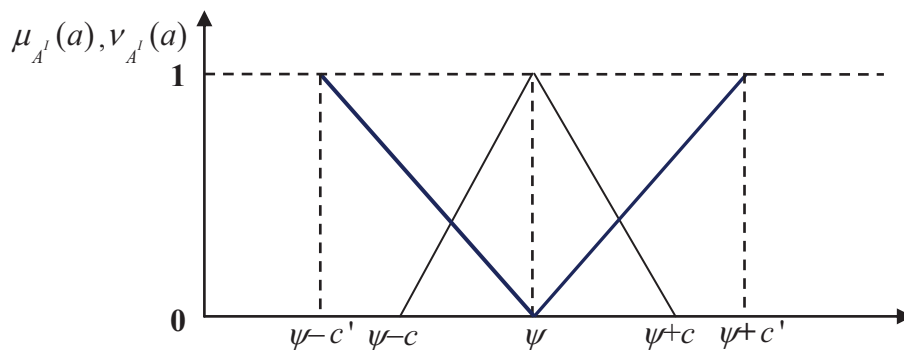
Fig 1. Illustration of triangular intuitionistic symmetrical FN

Definition 4 30 The support of an IFS A^I on $\Re$ is the crisp set of all $x \in \Re$ such that $\mu_{A^I}(x) > 0$, $v_{A^I}(x) > 0$ and $\mu_{A^I}(x) + v_{A^I}(x) \leq 1$.

Fuzzy Linear Regression with spreads unrestricted

The FLR analysis described in this section was first introduced by Tanaka et al. [13,3637) and the approach reviewed in this section is that modified by Chang and Lee 17, which proposed the FLR with spreads unrestricted 38.

Consider the general linear function $Y^* = f(\boldsymbol{x}, A)$, where $\boldsymbol{x} = (1, x_1, \ldots, x_n)^T$ represents the vector of non-fuzzy (crisp) inputs, $A = (A_0, A_1, \ldots, A_n)^T$ represents the vector of fuzzy parameters, respectively, and T stands for transpose. The fuzzy parameters A_k can be defined as the symmetrical triangular FNs, $A_k = (\psi_k, c_k)_L$, $k = 0, 1, \ldots, n$, and have the membership function

$$\mu_{A_k}(a_k) = \begin{cases} 1 - \dfrac{|\psi_k - a_k|}{c_k}, & if \ |\psi_k - a_k| \leq c_k, \\ 0, & otherwise. \end{cases} \qquad (5)$$

In vector notation, the parameters $A = (A_0, A_1, \ldots, A_n)^{\mathrm{T}}$ can also be written as

$$A = (\boldsymbol{\psi}, \boldsymbol{c}), \text{ where } \boldsymbol{\psi} = (\psi_0, \psi_1, \ldots, \psi_n)^{\mathrm{T}} \text{ and } \boldsymbol{c} = (c_0, c_1, \ldots, c_n)^{\mathrm{T}}. \tag{6}$$

Therefore, the estimated Y^* of the function can be obtained using the Zadeh extension principle or fuzzy arithmetic 3239 and results in the membership function

$$\mu_{Y^*(y)} = \begin{cases} 1 - \dfrac{|y - \boldsymbol{\psi}^{\mathrm{T}} \boldsymbol{x}|}{\boldsymbol{c}^{\mathrm{T}} |\boldsymbol{x}|}, & \boldsymbol{x} \neq \boldsymbol{0}, \\ 1, & \boldsymbol{x} = \boldsymbol{0},\ y = 0, \\ 0, & \boldsymbol{x} = \boldsymbol{0},\ y \neq 0, \end{cases} \tag{7}$$

where $|\boldsymbol{x}| = (1, |x_1|, \ldots, |x_n|)^{\mathrm{T}}$. The mode of Y^* is $\boldsymbol{\psi}^{\mathrm{T}} \boldsymbol{x}$ and spread of Y^* is $\boldsymbol{c}^{\mathrm{T}} |\boldsymbol{x}|$.

Suppose a set of crisp-input but fuzzy-output data $(Y_i, \boldsymbol{x}_i)$, $i = 1, \ldots, N$, available and $Y_i = (y_i, e_i)_L$. The membership functions of Y_i are defined as

$$\mu_{Y_i}(y) = \begin{cases} 1 - \dfrac{|y_i - y|}{e_i}, & \text{if } |y_i - y| \le e_i, \\ 0, & \text{otherwise.} \end{cases} \tag{8}$$

To obtain the fuzzy parameters A, the condition that $[Y_i]_\alpha \subset [Y_i^*]_\alpha \ \forall \alpha \ge H$ for all i holds may be imposed upon the FLR, where Y_i^* stands for the fuzzy estimate of Y_i and $H \in [0, 1)$ is a threshold level chosen by the decision-maker. In the FR analysis, H can be regarded as a measure of goodness of fit for the model. For instance, if $H = 0$, the estimated data completely enclose the observed data. The objective function of the FR can be defined as the minimization of total fuzziness (spreads) of the estimated outputs Y_i^*. Thus, Tanaka's FLR problem can be formulated as a linear programming (LP) problem 13 as follows:

$$\begin{aligned} & \textit{Minimize } J = Nc_0 + \sum_{i=1}^{N}(c_1 |x_{1i}| + \cdots + c_n |x_{ni}|) \\ & \textit{subject to all } c_k \ge 0, \textit{ and } \forall i = 1, \ldots, N, \\ & \boldsymbol{\psi}^{\mathrm{T}} \boldsymbol{x}_i + (1 - H)\boldsymbol{c}^{\mathrm{T}} |\boldsymbol{x}_i| \ge y_i + (1 - H)e_i, \\ & \boldsymbol{\psi}^{\mathrm{T}} \boldsymbol{x}_i - (1 - H)\boldsymbol{c}^{\mathrm{T}} |\boldsymbol{x}_i| \le y_i - (1 - H)e_i. \end{aligned} \tag{9}$$

Chang and Lee 17 proposed an alternative FLR in which the spreads are unrestricted ($c_k \in \Re$). This approach can effectively observe the trend of the dataset. Therefore, Chang and Lee's FLR problem can be formulated as follows:

$$Minimize\ J = Nc_0 + \sum_{i=1}^{N}(c_1|x_{1i}| + \cdots + c_n|x_{ni}|)$$

$$subject\ to\ all\ c_k \in \Re,\ and\ \forall i = 1,\ ...,\ N,$$

$$\boldsymbol{\psi}^T \boldsymbol{x}_i + (1-H)\boldsymbol{c}^T|\boldsymbol{x}_i| \geq y_i + (1-H)e_i,$$

$$\boldsymbol{\psi}^T \boldsymbol{x}_i - (1-H)\boldsymbol{c}^T|\boldsymbol{x}_i| \leq y_i - (1-H)e_i. \tag{10}$$

The solution yields the following FLR model:

$$Y^* = (\psi_0, c_0)_L + (\psi_1, c_1)_L x_1 + \cdots + (\psi_n, c_n)_L x_n \tag{11}$$

IFLR with spreads unrestricted

In this section the IFLR with spreads unrestricted is developed. IFLR 30 could not precisely represent the different trends of fuzzy data as traditional FLR. This weakness can be improved by spreads unrestricted techniques. Consider the general linear function $Y^I = f(\boldsymbol{x}, A^I)$, where $\boldsymbol{x} = (1, x_1, ..., x_n)^T$ represents the vector of non-fuzzy (crisp) inputs, and A^I represents the vector of IFLR spreads unrestricted parameter. The intuitionistic fuzzy parameter A^I can be defined as the symmetrical triangular IFSs, and $A^I = (\psi, c, c')$ has the membership function

$$\mu_{A^I}(x) = \begin{cases} (x-(\psi-c))/c, & for\ a \in [\psi-c, \psi], \\ ((\psi+c)-x)/c, & for\ a \in [\psi, \psi+c], \\ 0 & otherwise. \end{cases} \tag{12}$$

And

$$v_{A^I}(x) = \begin{cases} (\psi-x)/c', & for\ a \in [\psi-c', \psi], \\ (x-\psi)/c', & for\ a \in [\psi, \psi+c'], \\ 1 & otherwise. \end{cases} \tag{13}$$

The IFLR with spreads unrestricted coefficients are the symmetrical triangular IFSs. The IFLR with spreads unrestricted output from the linear model $f(\boldsymbol{x}, A^I)$ can be expressed according to the principle of extension as $Y^I = f(\boldsymbol{x}, A^I) = (f^{\psi}(x), f^{S_1}(x), f^{S_2}(x))$ where $f^{\psi}(x)$ $f^{S_1}(x)$, and $f^{S_2}(x)$ are respectively the center, spreads of membership, spreads of non-membership of the IFLR model $f(\boldsymbol{x}, A^I)$, and the estimated output. The objective function

of the IFLR with spreads unrestricted coefficients can be defined as the minimization of total fuzziness (spreads) of the estimated membership and non-membership. The spread η, which is to be minimized can be written as, Minimize $\eta = min\{ f^{S_1}(x) + f^{S_2}(x) \}$ and also as Minimize $\eta = N(c_0 + c_0^{'}) + (\sum_{i=1}^{N}((c_1 + c_1^{'})|x_{1i}| + \cdots + (c_n + c_n^{'})|x_{ni}|)$. The objective of the IFLR with spreads unrestricted coefficients is associated with $\mu_{Y^I}(y) \geq H$ and $v_{Y^I}(y) \leq 1 - K - H$ based on the condition that $[Y_i]_\alpha \subset [Y_i^{I*}]_\alpha \ \forall \alpha \geq H$ for all i holds may be imposed upon the IFLR where K is the intuitionistic index which represents non-membership of the element in the IFLR. Moreover, the values of K and H are chosen for the purpose of generating the best-fitting model. This study adopts the PSO algorithm to search the optimal parameters H and K in proposed model, and will be introduced in section 3. This model based on Chang and Lee modified Tanaka's FLR problem with spreads unrestricted coefficients can be formulated as an LP problem as follows:

$$Minimize \ \eta = N(c_0 + c_0^{'}) + (\sum_{i=1}^{N}((c_1 + c_1^{'})|x_{1i}| + \cdots + (c_n + c_n^{'})|x_{ni}|)$$

$$subject \ to \ all \ c_k, c_k^{'} \in \Re, \ and \ \forall i = 1, \ ..., \ N,$$

$$\psi^T x_i + (1-H)c^T|x_i| \geq y_i + (1-H)e_i,$$

$$\psi^T x_i + (1-K-H)(c^{'})^T|x_i| \geq y_i + (1-K-H)e_i, \tag{14}$$

$$\psi^T x_i - (1-H)c^T|x_i| \leq y_i - (1-H)e_i,$$

$$\psi^T x_i - (1-K-H)(c^{'})^T|x_i| \leq y_i - (1-K-H)e_i,$$

$$0 \leq K < 1, \ 0 \leq H < 1, \ K + H < 1.$$

The solution yields the IFLR with spreads unrestricted coefficients model:

$$Y^{I*} = (\psi_0, c_0, c_0^{'})_{LR} + (\psi_1, c_1, c_1^{'})_{LR} x_1 + \cdots + (\psi_n, c_n, c_n^{'})_{LR} x_n \tag{15}$$

The resulting estimated values of Y^{I*} are fuzzy A^I which can be defuzzified as a crisp value. The $A^I = (\psi, c, c^{'})$ can be transformed to a crisp number by employing 40, and the crisp Y^{I*} can be determined as follows:

$$Y^{I*} = \psi_0 + \frac{1}{6}(c_0^{'} - c_0) + (\psi_1 + \frac{1}{6}(c_1^{'} - c_1))x_1 + \cdots + (\psi_n + \frac{1}{6}(c_n^{'} - c_n))x_n \tag{16}$$

Therefore, the crisp number Y^{I*} is employed to estimate values after defuzzified method.

Proceedings of 2014 International Conference on
Technology Innovation and Industrial Management
28th-30th May 2014, Seoul, South Korea

INTUITIONISTIC FUZZY SEASONALITY REGRESSION WITH PSO

Seasonal time series prediction has been extensively investigated and used in many fields. In the literature, trend and seasonality have been modeled using different approaches. Intuitionistic FR should also consider the seasonality index. The seasonal time series is a sequence of seasonal data points recorded sequentially and chronologically. Seasonal variations can be directly explained from the fuzzy regression model constructed. Suppose there are $T+1$ sets of available data and each set t ($t=0, 1, \ldots, T$) has m seasonal data. The fuzzy seasonality must be defined, which leads to the following definition:

Definition 5 29 A time-series is called a fuzzy seasonality time-series if there is fuzziness involved in the seasonality. The fuzzy seasonality can be described as m ordinary subsets of $s_{k+t \times m}$ consisting of at least two different-valued elements thus far:

$$S_k^s = \left\{ s_k, s_{k+m}, \ldots, s_{k+t \times m}, \ldots, s_{k+T \times m} \right\}, k = 1, \ldots, m,$$

and S_k^s is called the *fuzzy seasonality index set* of seasonal k ($k=1,\ldots, m$).

In this study, a fuzzy forecast is a range of a forecast, but possessing a membership function accounting for the uncertainty that exists in time series. Producing a fuzzy forecast requires that a *fuzzy seasonality index* first be defined. This study defines the *fuzzy seasonality index* S_k^* from the *fuzzy seasonality index set* S_k^s as follow 29:

$$
\begin{aligned}
S_k^* &= (s_k^M, s_k^L, s_k^R)_{LR} \\
&= \left(\frac{\left(\sum_{w=0}^{W-1} s_{k+(T-w) \times m} \right)}{W}, \frac{\left(\sum_{w=0}^{W-1} s_{k+(T-w) \times m} \right)}{W} - \min(s_{k+(T-W+1) \times m}, s_{k+(T-W+2) \times m}, \ldots, s_{k+T \times m}) \right. , \\
&\qquad \left. , \max(s_{k+(T-W+1) \times m}, s_{k+(T-W+2) \times m}, \ldots, s_{k+T \times m})_{LR} - \frac{\left(\sum_{w=0}^{W-1} s_{k+(T-w) \times m} \right)}{W} \right)_{LR}
\end{aligned}
\tag{17}
$$

where s_k^M, s_k^L, s_k^R are *W-period smoothing-operators* ($1 \leq W \leq T$), *W-period spread of left*, and *W-period spread of right*, respectively. The S_k^* is defined as possessing a non-symmetrical triangular membership function.

This study proposes a novel seasonal technique IFSR, which uses the proposed IFLR with a spreads unrestricted model and a decomposition method, applying to the seasonal time series problem. In decomposition, a time series is examined using a multiplicative model. Moreover, IFLR with a spreads unrestricted model adopts symmetrical triangular FNs to forecast, and can

obtain a crisp estimated value through Eq. (16). Therefore, in the proposed novel model, a multiplicative model can obtain FNs based on a *fuzzy seasonality index*, which can be formulated as follows:

$$F_{k+(T+v)}^{I} = (f_{k+(T+v)}^{I*}(Trend) \times s_k^M \times \varepsilon, (f_{k+(T+v)}^{I*}(Trend) \times s_k^R \times \varepsilon - f_{k+(T+v)}^{I*}(Trend) \times s_k^L \times \varepsilon)/2)_{LR} \qquad (18)$$

where $F_{k+(T+v)}$ is the fuzzy forecast value of the time series, $f^{I*}(Trend)$ is the estimated value of trend which is calculated by the proposed IFLR with a spreads unrestricted model, and ε is the model noise. Fig. 5 shows the illustration of the proposed IFSR model.
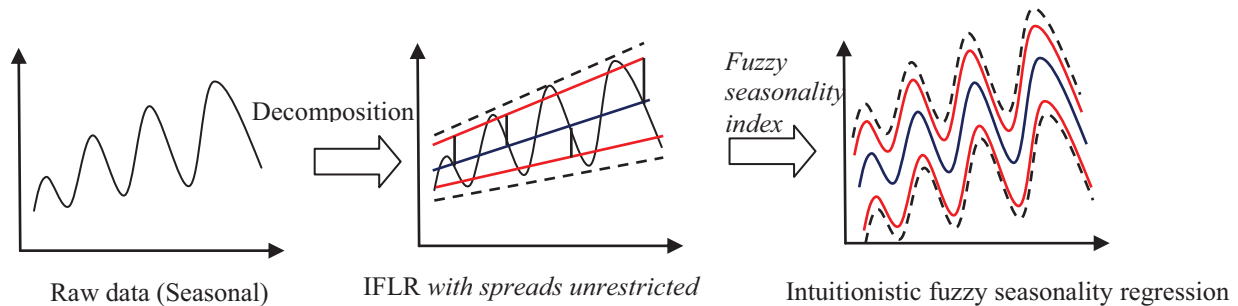
Fig 5. The illustration of proposed IFSR model.

The procedures of the proposed IFSR with PSO can be described as follows:

Step 1: The *fuzzy seasonality index* should be defined based on Eq. (17).

Step 2: In decomposition, a time series is examined using a multiplicative model. Therefore, the fuzzy trend data can be obtained from raw data divided by the *fuzzy seasonality index* (Fuzzy trend data = raw data/ S_k^*), which is a deseasonality technique.

Step 3: The use of fuzzy trend data can estimate the $f^{I*}(Trend)$ in the proposed IFLR with spreads unrestricted. The parameters (*H* and *K*) of IFLR with spreads unrestricted are searched using the PSO algorithm. The PSO algorithm will be briefly introduced in the following.

Step 4: The use of the multiplicative model can obtain as an estimated value $F_{k+(T+v)}$ by using Eq. (18).

Step 5: Performance criteria are calculated based on the estimated value and the performance criteria (MAPE(%) and RMSE), which are briefly introduced in the following paragraph.

Moreover, the interface of the proposed IFSR with PSO for assisting the user was also developed in this study. Fig. 6 displays the IFSR with PSO graphic interface.
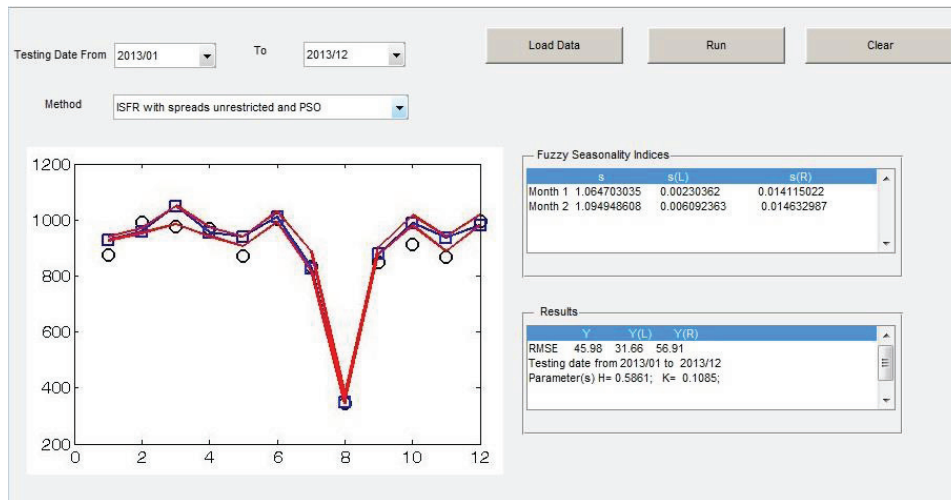
Fig 6. IFSR with PSO interface.

Basic principle of PSO — The IFLR with a spreads unrestricted model uses PSO to identify the two parameters *H*-level and intuitionistic index (*K*) that are used to discover the optimal performance of the proposed ISFR. PSO is a stochastic optimization technology. Kennedy 41 developed the method by modeling the social behavior of bird flocking and fish schooling. PSO is a population-based search that exploits a population to probe a promising region of the search space 42. First, initial populations are generated randomly, and each individual is also assigned a randomized velocity to fly them through the solution hyperspace. In the search space, each particle moves with velocity. The PSO will dynamically adjust and balance based on its own best movement (p_{best}) and the best position movement of the group (g_{best}). The modification of velocity (v_{id}) and position (x_{id}) of the *i*-th particle can be calculated using the current velocity and the distance from p_{best} to g_{best}, as follows:

$$v_{id}^{k} = w^{k}v_{id}^{k-1} + C_1 rand(.)(p_{best} - x_{id}^{k-1}) + C_2 rand(.)(g_{best} - x_{id}^{k-1}) \tag{19}$$

where C_1 and C_2 are two acceleration constants that regulate the velocities to the best global and local positions, respectively, and *k* is the current iteration number. The variable *rand*(.) refers to random variables with uniform distribution. The w^k is the inertia weight, which can be expressed as follows:

$$w^{k} = w_{max} - \frac{w_{max} - w_{min}}{k_{max}} \times k \tag{20}$$

where w_{max} is the initial weight, w_{min} is the final weight, k_{max} is the maximum number of iterations or generation. The new position of the particle is calculated as follows:

$$x_{id}^k = x_{id}^{k-1} + v_{id}^k \tag{21}$$

Both Eq. (19) and (20) are iterative until convergence of the search process is reached. In this study, the typical convergence criteria using a user-defined maximum number of iterations is employed.

Performance criteria — The root mean square error (RMSE) and the mean absolute percentage error (MAPE) were used to measure the forecasting accuracy of the model. Equations (22) and (23) illustrate the expressions of RMSE and MAPE (%), respectively.

$$\text{MAPE(\%)} = \frac{100}{M} \sum_{t=1}^{M} \left| \frac{Y_{Ct} - Y_C(x_t)}{Y_{Ct}} \right| \tag{22}$$

$$\text{RMSE} = \left\{ \frac{1}{M} \sum_{t=1}^{M} \left(Y_{Ct} - Y_C(x_t) \right)^2 \right\}^{0.5} \tag{23}$$

APPLICATION TO THE INDUSTRY SALES FORECASTING PROBLEM AND EXPERIMENTAL RESULTS

The data

In this research, an example of a monthly industry sales report for printing and writing paper, which represents typical seasonal time series data, was examined. Fig. 7 shows the monthly industry sales for printing and writing paper between the years 1963 and 1972. In Fig. 7, the seasonal pattern and a general increasing trend can be observed. The dominant seasonal pattern is clearly revealed in the smaller value for August. The real line in Fig. 7 represents the linear regression model and, in this example, the rising trend can be observed. The example of a monthly industry sales report for printing and writing paper can refer to 43.

For all models, experimental data are divided into training (during the years 1963–1970), validation (1971), and testing data sets (1972). Table 3 shows the experimental data employed in this study for all models. The training data set was used to determine the forecasting model; the validation data set was used to prevent over-fitting the forecasting models; and the testing data set was employed to investigate the performance of different forecasting models. For the example, the training data set and the validation set are used to design IFSR with spreads unrestricted and the PSO model. To compare the forecasting accuracy, the same testing data set is examined in various forecasting models.

   Based on procedures employed in the proposed IFSR, the *fuzzy seasonality index* is computed as listed in Table 4. The maximum fuzziness of the *fuzzy seasonality index* is in July (k=7), which denotes a higher degree of uncertainty. The estimated values of trend ($f^*(Trend)$ and $f^{1*}(Trend)$), which were computed based on Chang and Lee's FLR and the proposed IFSR with PSO, respectively, were examined, and the fuzzy results are provided in Table 4. The proposed IFSR method can achieve a superior performance (MAPE(%) and RMSE). Fig. 7 makes a point-to-point comparison of the actual values and the fuzzy predicted values of the FSR(Chang and Lee's FLR with H=0.5861) and proposed IFSR with PSO (H=0.5861 and K=0.1085), respectively, and shows that the proposed IFSR model can efficiently capture the data, particularly estimated lower bound f^{IL} MAPE(%) is 2.836 and RMSE is 31.667. This is evidence that the IFSR with PSO should be considered to assist the traditional FSR model in achieving stronger performances.
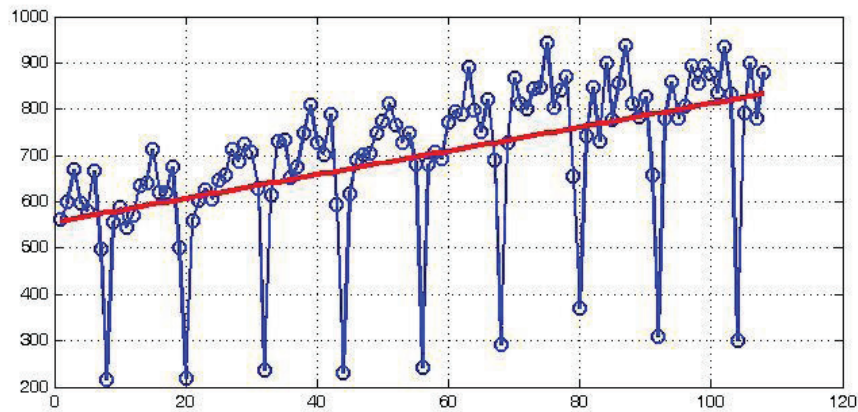
Fig7. Monthly industry sales for printing and writing paper from Jan. 1963 through Dec. 1972.

Table 3. The experimental data.

Month(k)	Training data(Monthly sales in 1963 to 1970)								Validation set (Monthly sales in 1971)	Testing data(Monthly sales in 1972)
	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	562.674	634.712	646.783	676.16	747.636	795.337	843.038	778.139	895.217	875.024
2	599.000	639.283	658.442	748.18	773.392	788.421	847.000	856.075	856.075	992.968
3	668.516	712.182	712.906	810.68	813.788	889.968	941.952	938.833	893.268	976.804
4	597.798	621.557	687.714	729.36	766.713	797.393	804.309	813.023	875.000	968.697
5	579.889	621.000	723.916	701.11	728.875	751.000	840.307	783.417	835.088	871.675
6	668.233	675.989	707.183	790.08	749.197	821.255	871.528	828.11	934.595	1000.852
7	499.232	501.322	629.000	594.62	680.954	691.605	656.33	657.311	832.500	832.037
8	**215.187**	**220.286**	**237.53**	**230.72**	**241.424**	**290.655**	**370.508**	**310.032**	**300.000**	**345.587**
9	555.813	560.727	613.296	617.19	680.234	727.147	742.000	780.000	791.443	849.528
10	586.935	602.53	730.444	691.39	708.326	868.355	847.152	860.000	900.000	913.871
11	546.136	626.379	734.925	701.07	694.238	812.39	731.675	780.000	781.729	868.746
12	571.111	605.508	651.812	705.78	772.071	799.556	898.527	807.993	880.000	993.733

Table 4. Comparison of results of fuzzy seasonality regression (Chang and Lee's FLR) with IFSR with spreads unrestricted and PSO.

Month (k)	Actual value (1972 year)	Fuzzy seasonality regression (Chang and Lee's FLR with $H=0.5861$)								IFSR with PSO ($H=0.5861$ and $K=0.1085$)			
		s_k^M	s_k^L	s_k^R	$s_k^L + s_k^R$	$f^*(Trend)$	f^M	f^L	f^R	$f^{I*}(Trend)$	f^{IM}	f^{IL}	f^{IR}
1	875.024	1.051	0.002	0.014	0.016	913.766	959.992	2.105	12.898	883.148	927.824	2.034	12.466
2	992.968	1.080	0.006	0.015	0.021	917.226	990.894	5.588	13.422	886.316	957.501	5.400	12.969
3	976.804	1.179	0.071	0.002	0.073	920.687	1085.222	65.652	1.852	889.484	1048.442	63.427	1.789
4	968.697	1.069	0.014	0.023	0.037	924.147	987.599	13.083	21.369	892.652	953.941	12.637	20.641
5	871.675	1.048	0.037	0.000	0.038	927.608	972.298	34.770	0.166	895.820	938.979	33.579	0.160
6	1000.852	1.125	0.022	0.021	0.043	931.068	1047.518	20.720	19.593	898.987	1011.425	20.006	18.918
7	832.037	0.917	0.009	0.069	0.078	934.529	856.937	8.357	64.218	902.155	827.252	8.068	61.994
8	345.587	0.386	0.004	0.029	0.033	937.989	361.895	3.304	27.244	905.323	349.292	3.189	26.295
9	849.528	0.969	0.003	0.025	0.029	941.450	912.134	3.110	23.829	908.491	880.202	3.001	22.995
10	913.871	1.085	0.011	0.030	0.041	944.910	1025.216	10.268	28.621	911.659	989.139	9.907	27.614
11	868.746	1.023	0.053	0.004	0.057	948.370	970.430	50.191	3.483	914.827	936.106	48.416	3.360
12	993.733	1.069	0.001	0.041	0.042	951.831	1017.105	0.637	39.018	917.995	980.949	0.614	37.631
MAPE(%)							6.708	4.783	9.429		4.148	2.836	6.026
RMSE							70.550	50.961	86.549		45.990	31.667	56.913

○ Actual value —— fuzzy bounds ◇ estimated value (f^M) ⊟ estimated value (f^{IM})
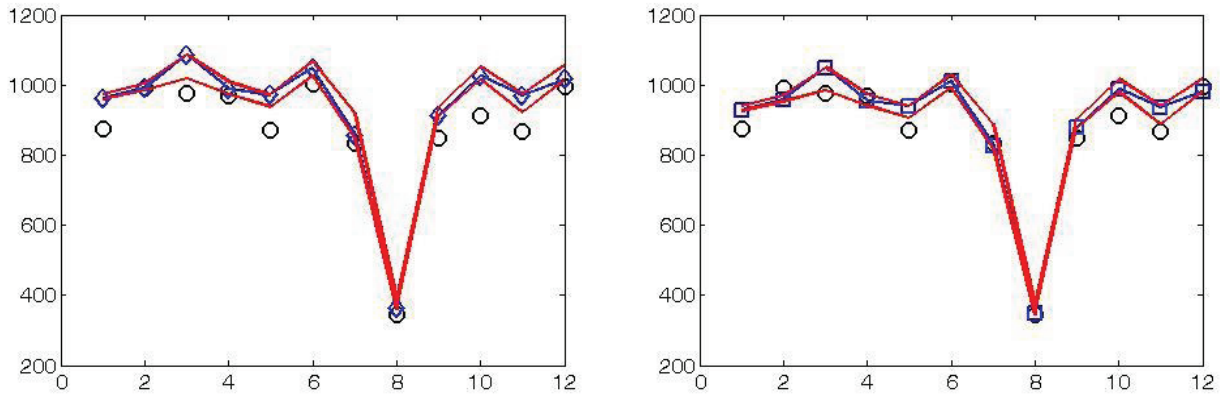
(a) Fuzzy seasonality regression   (b) IFSR with PSO

Fig 7. Illustration of the actual values and the fuzzy predicted values.

Furthermore, to demonstrate the superiority of the proposed IFSR with spreads unrestricted and the PSO model, three other forecasting models were applied: support vector regression (SVR) 10, SARIMA 1, and seasonal support vector regression (SSVR) 10. The comparison models used in this research are briefly introduced here.

Fig. 8 illustrates point-to-point plots of testing data for the SVR, SARIMA, SSVR, and IFSR with PSO. Fig. 8 reveals that the actual value is lower than others in August 1972, and the SVR models do not capture the trend of the data well, whereas the SARIM, SSVR, and proposed IFSR models can accurately gauge this trend. The superiority of the proposed IFSR model is primarily because of its ability to handle seasonal variance when using a *fuzzy seasonality index*. The proposed IFLR with PSO can correctly estimate trends. Again, this is evidence that the IFLR/FLR should be extended to consider the spreads unrestricted and the *fuzzy seasonality index*.

Table 5. Comparison of forecasting performances and parameters of four models

Month(k)	Actual value (1972 year)	SVR (σ, C, ε) =(2.5, 2549.53, 0.023)	SARIMA $(p, d, q)(P, D, Q)_S$=(2, 1, 1) (0, 1, 2)$_{12}$	SSVR (σ, C, ε) =(6.947, 994.83, 9.59	IFSR with PSO (f^{IL}) H=0.5861 and K=0.1085
1	875.024	838.24	883.319	860.9	925.79
2	992.968	842.84	896.97	899.46	952.1009
3	976.804	873.12	963.852	1000.9	985.0154
4	968.697	876.37	887.607	896.22	941.3033
5	871.675	878.67	869.248	888.52	905.3999
6	1000.852	873.87	925.257	939.41	991.4191
7	832.037	880.57	784.076	765.51	819.1837
8	345.587	875.37	386.134	330.91	346.1029
9	849.528	873.35	816.222	827.42	877.2008
10	913.871	874.05	907.938	926.68	979.2322
11	868.746	875.02	845.055	885.75	887.69
12	993.733	875.65	892.58	911.6	980.3343
MAPE(%)		19.32145	5.2598	4.6267	2.836
RMSE		172.8411	55.9987	50.9613	31.667
Ranking		(4)	(3)	(2)	(1)
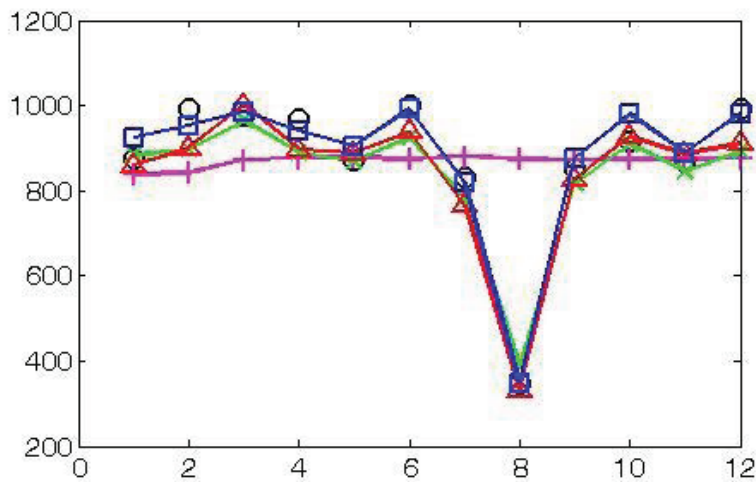
Fig 8. Illustration of actual values and forecasting values of four models

CONCLUSIONS

Based on the research of spreads unrestricted, fuzzy seasonality, and the intuitionistic FR model, this study successfully developed an IFSR with a PSO model that exploits the unique strength of decomposition techniques and intuitionistic FR to forecast industry sales for printing and writing paper. Empirical results showed that the IFSR with PSO model is a feasible and useful method to forecast seasonal time series data. The superior performance of the IFSR with PSO model can be ascribed to three causes. First, the *fuzzy seasonality index*, which can interpret the uncertainty of data, thereby enhancing the ability of the IFSR with PSO model to capture seasonal time series data patterns. Second, the IFSR with PSO model, which is based on a proposed IFLR with spreads unrestricted, can efficiently capture the trends of data. Third, the PSO can effectively improve the performance of the proposed IFSR. This study is the first attempt to use an IFLR method with spreads unrestricted and a *fuzzy seasonality index* to forecast seasonal time series data. The forecasting of other types of seasonal time series data, using the IFSR with PSO model, is a challenging topic worthy of further study. Future studies should also consider using data preprocessing techniques or fuzzy inference systems, which can effectively reduce the seasonal variance, to improve the forecasting accuracy of the IFSR with PSO model.

REFERENCE

1. G. Box, G. Jenkins, Time Series Analysis: Forecasting and Control, Holden-Day, San Francisco, 1976.
2. T. Li, E.P. Campbell, D. Haswell, R.J. Sneeuwjagt, W.N. Venables, Statistical forecasting of soil dryness index in the southwest of western Australia, Forest Ecology and Management 183 (2003) 147–157.
3. C. Goh, R. Law, Modeling and forecasting tourism demand for arrivals with stochastic nonstationary seasonality and intervention, Tourism Management 23 (2002) 499–510.
4. J.-H. Huang, J.C.-H. Min, Earthquake devastation and recovery in tourism: the Taiwan case, Tourism Management 23 (2002) 145–154.
5. J. Navarro-Esbrí, E. Diamadopoulos, D. Ginestar, Time series analysis and forecasting techniques for municipal solid waste management, Resources, Conservation and Recycling 35 (2002) 201–214.
6. G.P. Zhang, M. Qi, Neural network forecasting for seasonal and trend time series, European Journal of Operational Research160 (2005) 501–514.
7. C. Hamzaçebi, Improving artificial neural networks' performance in seasonal time series forecasting, Information Sciences 178 (2008) 4550–4559.

8. K. Nam, T. Schaefer, Forecasting international airline passenger traffic using neural networks, Logistics and Transportation Review 31 (1995) 239–251.

9. P.-F. Pai, W.-C. Hong, An improved neural network model in forecasting tourist arrivals, Annals of Tourism Research 32 (2005) 1138–1141.

10. P.-F. Pai, K.-P. Lin, C.-S. Lin, P.-T. Chang, Time series forecasting by a seasonal support vector regression model, Expert Systems with Applications 37 (2010) 4261–4265.

11. P.M. Williams, Modelling seasonality and trends in daily rainfall data, Advances in Neural Information Processing Systems 10 (1997) 985–991.

12. F.-M. Tseng, G.-H. Tzeng, H.-C. Yu, Fuzzy Seasonal Time series for forecasting the production value of the mechanical industry in Taiwan, Technological Forecasting and Social Change 60 (1999) 263–273.

13. H. Tanaka, S. Uejima, K. Asai, Fuzzy linear regression model, in *Proc. International Congress on Applied Systems Research and Cybernetics*, 1980, pp. 12–16.

14. K.J. Kim, H. Moskowitz, M. Koksalan, Fuzzy versus statistical linear regression, European Journal of Operational Research 92 (1996) 417–434.

15. A. Bisserier, R. Boukezzoula, S. Galichet, A revisited approach to linear fuzzy regression using trapezoidal fuzzy intervals, Information Sciences 180 (2010) 3653–3673.

16. K.Y. Chan, C.K. Kwong, T.C. Fogarty, Modeling manufacturing processes using a genetic programming-based fuzzy regression with detection of outliers, Information Sciences 180 (2010) 506–518.

17. P.-T. Chang, E.S. Lee, Fuzzy linear regression with spreads unrestricted in sign, Computers and Mathematics with Applications 28 (1994a) 61–70.

18. P.-T. Chang, E.S. Lee, Fuzzy least absolute deviations regression and the conflicting trends in fuzzy parameters, Computers and Mathematics with Applications 28 (1994b) 89–101.

19. P.-T. Chang, K.-P. Lin, C.-S. Lin, K.-C. Hung, L.-T. Hung, B.-D. Hsu, Developing a fuzzy bi-cluster regression to estimate heat tolerance of plants by chlorophyll fluorescence, IEEE Transactions on Fuzzy Systems 17 (2009) 485 –504.

20. P. D'Urso, R. Massari, A. Santoro, A class of fuzzy clusterwise regression models, Information Sciences 180 (2010) 4737–4762.

21. P. D'Urso, R. Massari, A. Santoro, Robust fuzzy regression analysis, Information Sciences 181 (2011) 4154–4174.

22. J. Kacprzyk, M. Fdrizzi, Fuzzy Regression Analysis, Ommitech Press and Physica-Verlag, Heidelberg, 1992.

23. S.W. Lee, D.S. Kim, M.G. Na, Prediction of DNBR using fuzzy support vector regression and uncertainty analysis, IEEE transactions on nuclear science 57 (2010) 1595–1601.

24. K.-P. Lin, P.-F. Pai, A fuzzy support vector regression model for business cycle predictions, Expert Systems with Applications 37 (2010) 5430–5435.

25. M. Sakawa, H. Yano, Multiobjective fuzzy linear regression models, Fuzzy Sets and Systems 47 (1992) 173–181.

26. H. Tanaka, I. Hayashi, J. Watada, Possibilistic linear regression analysis for fuzzy data, European Journal of Operational Research 40 (1989) 389–396.

27. J. Watada, S. Wang, W. pedrycz, Building confidence-interval-based fuzzy random regression models, IEEE Transactions on Fuzzy systems 17 (2009) 1273–1283.

28. Y.R. Fan, G.H. Huang, A.L. Yang, Generalized fuzzy linear programming for decision making under uncertainty: Feasibility of fuzzy solutions and solving approach, Information Sciences 241 (2013) 12–27.

29. P.-T. Chang, Fuzzy seasonality forecasting, Fuzzy Sets and Systems 90 (1997) 1–10.

30. R. Parvathi, C. Malathi, M. Akram, K.T. Atanassov, Intuitionistic fuzzy linear regression analysis, Fuzzy Optimization and Decision Making 12 (2013) 215–229.

31. L. A. Zadeh, Fuzzy sets, Information and Control 8 (1965) 338–353.

32. D. Dubois, H. Prade, Fuzzy Sets and Systems: Theory and Applications, Academic Press, New York, 1980.

33. K.T. Atanassov, Intuitionistic fuzzy sets, Fuzzy Sets and Systems 20 (1986) 87–96.

34. P. Burillo, H. Bustince, Entropy on intuitionistic fuzzy set and on interval-valued fuzzy set, Fuzzy Sets and Systems 78 (1996) 305–316.

35. G.S. Mahapatra, T.K. Roy, Reliability evaluation using triangular intuitionistic fuzzy numbers arithmetic operations, International Journal of Mathematical and Statistical Sciences 1 (2009) 31–38.

36. J. Watada, H. Tanaka, T. Shimomura, Identification of learning curve based on possibility concepts, in: W. Karwowski (Ed.), Applications of Fuzzy Set Theory in Human Factors, Elsevier, Amsterdam, Netherlands,1986, pp.191–208.

37. H. Tanaka, Fuzzy data analysis by possibilistic linear models, Fuzzy Sets and Systems 24 (1987) 363–375.

38. P.-T. Chang, E.S. Lee, S.A. Konz, Applying fuzzy linear regression to VDT legibility, Fuzzy Sets and Systems 80 (1996) 197–204.

39. A. Kaufmann, M.M. Gupta, Introduction to Fuzzy Arithmetic: Theory and Applications. Van Nostrand-Reinhold, New York, 1985.

40. D.G. Kleinbaum, L.L. Kupper, Applied Regression Analysis and Other Multivariable methods, Wadsworth, Belmont CA, 1978.

41. J. Kennedy, The Particle Swarm: Social Adaptation of Knowledge, in Proc. IEEE Int. Conf. Evol. Comput., Indianapolis, IN, 1997, pp. 303-308.

42. X. Li, S. Ming, D. Lixing, Particle swarm optimization-based LS-SVM for building cooling load prediction, Journal of Computers 5 (2010) 614-621.

43. S. Makridakis, S.C. Wheelwright, R.J. Hyndman, Forecasting: Methods and Applications. Wiley & Sons, New York, 1998.

44. V. Vapnic, Statistical Learning Theory, Wiley, New York, 1998.

CONSTRUCTING A NOVEL PROCESSES FOR MEASURING THE OPTIMAL HEDGE STRATEGY IN EXCHANGE RISK FOR IT INDUSTRY

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ABSTRACT

Subject to the increase of the liberalization of financial markets, the performance of the business is significantly related to the market risk. Therefore, the company usually utilized high financial leverage of derivatives to hedge the risk. When the company chose different hedging instruments to faced a variety of exchange rate risk, therefore we employ the Multinomial Logistic-AHP to analyze the impact of various derivatives. Hence, the research summarized by the literature relevant factors affecting managers selected exchange rate hedging instruments, furthermore, using Multinomial Logistic Model and and further integrate AHP. Using Experts' Questionnaires can test multi-level selection and hedging effect of different hedging instruments in order to calculate the hedging instruments and the multi-level factors of weights to understand the gap between the empirical results and practical operation. Finally, the Multinomial Logistic-AHP Model will sorted the weights to analyze. The research findings can be a basis reference for investors in decision-making.

Keywords: Exchange rate risk, Derivatives, Hedge, Multinomial Logistic－AHP

EMPIRICAL ANALYSIS OF INFORMATION EFFECT OF INDUSTRIAL INCIDENT IN THE CROSS-STRAIT DIVISION MODEL BETWEEN TAIWAN AND CHINA

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Purpose: Recently, international trade has been deeply affected by the trend of industrial specialization, and it has been an important developmental strategy for multinational corporations to establish production base in oversea countries. Moreover, the shortage of raw materials, the increasing of wage, the price of lands, and the legal issues due to environmental conservation have made Taiwan lose its competitive advantage in labor-intensive industries. In order to pursue a bigger market, abundant resources, and lower cost, enterprises have gradually established production base in oversea countries. This study tries to analyze the explanatory variables which affect by cross-sectional regression analysis. The empirical findings perhaps can be a reference benchmark for Taiwanese companies in decision-making.

Design/methodology/approach: The data sources used for this study investigates the listing companies in Taiwan. The data are sourced from TEJ. This study used GARCH risk-adjustment model to investigate Taiwanese listed companies in which industrial incidents once occurred in their China production base from January 1, 2006 to December 31, 2013, and aims to find out how their Taiwan headquarter companies' stock prices react to those incidents and whether there are information asymmetry and conceal a reality or not. If the industrial incidents occurred period is too close, will choice the data which the first occurred. After deleting close period, he number of samples is 26. In addition, this study tries to analyze the explanatory variables which affect by cross-strait regression analysis.

Findings/conclusions: *The empirical results are expected the work on corporate research of information security event to provide more complete disclosure of evidence and may provide investors with security incidents while working as a reference for their relevant business investment, and benchmark for Taiwanese companies in decision-making.*

INTEGRATED SCHEDULING OF MULTI-FACTORY SUPPLY CHAIN WITH SHIPPING INFORMATION

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ABSTRACT

The paper considers a supply chain of a multi-site manufacturing system, which consists of overseas customers and domestic plants. Due to difference in geographical location and labor cost, the cost of an order depends on the plant to be assigned. The finished order is delivered to the customers in different transportation situations. The first situation involves transportation from the factory to the terminal. The second appears in the environment of delivering a finished job to the customer overseas from the terminal. For the first situation, we combine it with the production schedules in the factory, which forms a flow shop manufacturing system. In the second one, the main constraint for the scheduling is the shipment schedules, which means fixed delivery times, limited vehicles with different transportation modes. Our objective is to determine the job assignment to appropriate factories and job processing sequence in each factory together with the delivery schedule under the consideration of customers' service level so as to minimize the sum of costs both on production and distribution. We propose a modified MILP formulation to solve a small-scale problem in polynomial time and demonstrate the significance of the proposed model.

Keywords: Linear Programming; Multi-factory; Production and distribution scheduling; Due date

INTRODUCTION

In order to achieve better quality, reduce production cost and management risk in the process of globalization, multi-site manufacturing systems have become more and more popular. As the

core of the supply chain model, production and distribution scheduling problems need more exploration. Many researchers have studied integrated production and distribution problems so as to realize quick responses to customers at minimum cost in the single-factory manufacturing system. However, integrated production and distribution scheduling problems in multi-site manufacturing systems are much more complicated because they involve the allocation of jobs to machines in different factories, which are geographically distributed, so as to utilize the maximum resources.

In this study, two different transportation situations are considered simultaneously and linked to each other appropriately. The main constraint for the transportation policy is the shipment information, which means fixed delivery times, and limited vehicles with different transportation modes. It is different from many studies where transportation is always assumed to be available and unlimited, or its delivery time and cost required are simplified to be identical during the distribution scheduling.

Our objective is to determine the production planning and distribution scheduling in the multi-factory manufacturing system with the consideration of transportation constraints and customers' service level so as to minimize the sum of costs for both production and distribution. A modified mixed integer linear programming is proposed and the performance of the model is demonstrated by numerical experiment.

This paper is divided into the following sections. Section 2 is a literature review. Section 3 describes the problem background and a modified MILP formulation. Section 4 presents the optimization result and significance of the proposed model by numerical experiment. Section 5 will be the conclusions.

LITERATURE REVIEW

In recent decades, production and distribution scheduling problem of multi-site manufacturing system get more exploration (Timpe and Kallrath 2000, Thoney *et al.* 2002, Gnoni *et al.* 2003, Garcia *et al.* 2004, Chen and Pundoor 2006, De Giovanni and Pezzella 2010, Chan *et al.* 2012). As quick response is becoming more critical in many make-to-order supply chains, the relationship between production and distribution is becoming ever closer. Consequently, production and distribution must be jointly scheduled so as to realize quick response to customers at minimum cost(Chen and Pundoor 2006, Chen 2010).DS problems in multi-factory production are much more complicated because they involve the allocation of jobs to machines in different factories which are geographically distributed so that it can utilize the maximum resources (Chan *et al.* 2012).

In a multi-factory production model, the factories can be structured in parallel or in series. A parallel structure model means each factory may produce the finished products and supply to the customers directly(Chan *et al.* 2005), while a series structure model means the output from one factory becomes an input into another factory(Safaei *et al.* 2009, Chung *et al.* 2010). In this paper, the factories that are available to process the jobs have different speeds in which each factory has parallel identical production lines.

Transportation as a critical factor linking the supplier with the customers, always gets huge interest from researchers. Some studies constrain the model with limited vehicles (Garcia *et al.* 2004, Li *et al.* 2005), or with limited capacity but sufficient vehicles (Chen and Vairaktarakis 2005). Stecke and Zhao (2007) consider a model of integrated production and transportation scheduling which partial delivery is allowed. Partial delivery means the manufacturer could divide a customer's order into small ones and ship them separately. To ease handling, the customer may prefer that an order be delivered wholly in one shipment. However, allowing order delivery partially may improve service level or lower distribution cost. In that case, Chen and Pundoor (2009) establish models that orders can be produced and shipped in either non-splittable or splittable way. Only a few papers discuss different shipping modes in their models of the synchronization of manufacturing and product delivery but in the single machine environment (Wang and Lee 2005, Stecke and Zhao 2007). Different transportation modes involve different cost structures and delivery times. For instance, the one with a shorter delivery time costs more. Lee and Chen (2001) study two types of transportation situations. The first situation involves transportation among machines. The second appears in the environment of delivering a finished job to the customer or warehouse. Both transportation times and capacity are explicitly taken into account in the model.

The paper study a model of a multi-site manufacturing system with fixed delivery times, limited vehicles with different transportation modes. Production cost will be considered as well. According to the knowledge of the authors, no research to date addresses this model.

METHODOLOGY

Problem background

In the paper, the production planning and distribution scheduling problem is addressed with the consideration of shipping information under the multi-factory environment with unrelated parallel production lines. There are n jobs $J = \{1,2,\dots,n\}$ from the overseas customers and m factories $M = \{1,2,\dots,m\}$ domestically located at different locations with total k production lines $I = \{1,2,\dots,k\}$. The jobs would be transported to terminals $T = \{1,2\dots,t\}$ after completion and be shipped by the vessels $S = \{1,2,\dots,s\}$ berthed at the terminals to the overseas customers.

The job would be stored in the warehouse and not depart from the warehouse until it is almost the available time of the vessel. On the other hand, the job would be saved in the overseas distribution center immediately after the shipment if the due date is not yet met.

The proposed mathematical model determines the optimal scheduling program to minimize the total costs by integrating the production planning and distribution scheduling in the multi-factory environment.

Decision Variable

x_{ijk}	= 1, if job j is assigned with service preceding job k on production line i
	= 0, otherwise
y_{ijs}	= 1, job j produced by production line i is delivered by vessel s
	= 0

Variables

s_j	starting production time of job j
c_j	completion time of job j in the factory
r_j	arrival time at distribution center of job j

Set

I	the set of production lines
J	the set of jobs
S	the set of vessels
T	the set of terminals

Input data

p_{ij}	processing time of job j on the production line i
q_j	quantity of job j
d_j	due date of job j
tr_{it}	travelling time from the factory with the production line i to terminal t
a_s	available time of vessel s
t_s	shipping lead time of vessel s
T_{st}	information of vessel s at terminal t
c_{ij}^{pro}	unit production cost of job j on production line i
$c_j^{w_i}$	unit storage cost of job j in the warehouse w_i near to the factory with production line i per day
c_{it}^{tr}	unit travelling cost from the factory with the production line i to terminal t
c_s	unit shipping cost of vessel s
c_j^{DC}	unit storage cost of job j in distribution center per day
c_j^p	unit penalty cost of tardiness for job j per day

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Objective function

$$Z = \text{Min} \sum_{j \in J} q_j (c_j^{pro} + c_j^w + c_j^{tr} + c_{js} + c_j^{DC} h_j^{DC} + c_j^p l_j) \qquad (1)$$

where,

$$c_j^{pro} = \sum_{i \in I} \sum_{k \neq j, \in J \cup o(e)} c_{ij}^{pro} x_{ijk}, \qquad (2)$$

Objective function (1) aims at minimizing the sum of the cost of all jobs generated throughout the supply chain, which includes production cost, travelling cost, storage cost in warehouse, shipping cost, storage cost of distribution center, and penalty cost. Equation (2) defines the unit production cost of job j.

$$c_j^w = \sum_{i \in I} c_j^{w_i} h_j^{w_i}, \qquad (3)$$

where,

$$h_j^{w_i} = \max(w_{ij} - c_j, 0), \qquad (4)$$

where,

$$w_{ij} = \sum_{s \in S} y_{ijs} a_s - \sum_{s \in S} \sum_{t \in T} y_{ijs} T_{st} tr_{it}, \qquad (5)$$

Equation (3) defines the unit storage cost of job j in the warehouse w_i close to the factory with production line i. Equation (4) defines the holding days of job j in the warehouse w_i close to the factory with production line i. Equation (5) defines the departure time of job j from the warehouse w_i which is close to the factory with production line i.

$$c_j^{tr} = \sum_{i \in I} \sum_{t \in T} \sum_{s \in S} y_{ijs} T_{st} c_{it}^{tr}, \qquad (6)$$

$$c_{js} = \sum_{i \in I} \sum_{s \in S} y_{ijs} c_s, \qquad (7)$$

If the vessel s is available at terminal t, $T_{st} = 1$, otherwise $T_{st} = 0$. Equation (6) defines the travelling cost of job j per quantity. Equation (7) defines the shipping cost of job j per quantity.

$$h_j^{DC} = \max(d_j - r_j, 0), \qquad (8)$$

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$$l_j = \max(r_j - d_j, 0), \tag{9}$$

Equations (8) and (9) define the earliness and tardiness of job as the difference between its arrival time at distribution center and due date.

Constraints:

Two dummy jobs $o(s)$ and $o(e)$ are set in this model as the starting point and ending point of the sequence of jobs scheduled in each production line, whose processing times are zero. The starting point $o(s)$ precedes the 'first' job assigned to the production line, while the ending point $o(e)$ is preceded by the 'last' job assigned to the production line.

$$\sum_{i \in I} \sum_{k \neq j, \in J \cup o(e)} x_{ijk} = 1 \quad \forall j \in J, \tag{10}$$

$$\sum_{i \in I} \sum_{j \neq k, \in J \cup o(s)} x_{ijk} = 1 \quad \forall k \in J, \tag{11}$$

Constraints (10) state that each job is assigned to only one production line and immediately precedes at most another one job. Constraints (11) state that each job is assigned to only one production line and is immediately preceded by at most another one job.

$$\sum_{j \in J \cup o(s)} \sum_{n \in J \cup o(e)} (x_{ijk} - x_{ikn}) = 1 \quad \forall k \in J; i \in I, \tag{12}$$

$$\sum_{k \in J \cup o(e)} x_{io(s)k} = 1 \quad \forall i \in I, \tag{13}$$

$$\sum_{j \in J \cup o(s)} x_{ijo(e)} = 1 \quad \forall i \in I, \tag{14}$$

Constraints (12) guarantee that each job has one immediate predecessor and one immediate successor. Constraints (13) limit that only one job is assigned as the 'first' job for each factory. Constraints (14) limit only one job is assigned as the 'last' job for each production line.

$$x_{ijk} + x_{ikj} \leq 1 \quad \forall i \in I; j \in J; k \in J, j \neq k, \tag{15}$$

Constraints (15) reinforces the precedence relations between any pair of jobs j and k. Either j immediately precedes k or k immediately precedes j (if both are scheduled to the same production line), or neither relation holds.

$$c_j = s_j + \sum_{i \in I} \sum_{k \neq j \in J \cup o(e)} x_{ijk} p_{ij} \quad \forall j \in J, \tag{16}$$

$$s_k - s_j \geq \sum_{i \in I} x_{ijk} p_{ij} - N \left(1 - \sum_{i \in I} x_{ijk}\right) \quad \forall j \in J; k \in J, j \neq k, \tag{17}$$

Constraints (16) set the completion time of j to the sum of its starting and processing time. Constraints (17) relates the starting times of two successive jobs on the same production line. N is a large positive number such that $N \rightarrow \infty$.

$$\sum_{i \in I} \sum_{s \in S} y_{ijs} = 1 \quad \forall j \in J, \tag{18}$$

Constraints (18) state that each job is finished by exact one production line and shipped by exact one vessel.

$$r_j = \sum_{i \in I} \sum_{s \in S} y_{ijs}(a_s + t_s) \quad \forall j \in J, \tag{19}$$

$$\sum_{i \in I} \sum_{s \in S} y_{ijs} a_s - \sum_{i \in I} \sum_{s \in S} \sum_{t \in T} y_{ijs} T_{st} tr_{it} \geq c_j \quad \forall j \in J, \tag{20}$$

Constraints (19) set the arrival time of job j at distribution center to the sum of the available time and shipping lead time of the vessel to which job j is assigned. Constraints (20) limit the departure time of each job from the warehouse is not earlier than its completion time of production in the factory.

$$\sum_{k \in J \cup o(e)} x_{ijk} - \sum_{t \in T} \sum_{s \in S} y_{ijs} T_{st} = 0 \quad \forall i \in I; j \in J, \tag{21}$$

Constraints (21) relate the factory with the production line to which job j is assigned with the vessel by which it would be shipped from terminal.

NUMERICAL EXPERIMENT

We conduct a numerical experiment to test the significance of the integrated production planning with the multi-factory environment. We test the problems with 10 orders, 3 production lines (two of them are from the factory with lower unit production cost) and 40 vessels. And test problems are randomly generated as follows:

a. The difference of unit production costs c_{ij}^{pro} between the factories is 30% and the unit warehouse storage cost c_j^{wi} is 2% of the unit production cost c_{ij}^{pro}. The unit processing time in the "expensive" factory is 20% more than that in the "cheaper" factory. And the quantity of each job q_j is randomly generated by normal distribution. Unit penalty cost and the due date of each job are respectively generated randomly, around 30%~50% of unit production cost, and equal to the expected time for production and shipping with 10% deviation.

b. The unit transportation cost equal to $5\% c_{ij}^{pro} tr_{it}$.

c. The average number of vessels available at terminal 1 per day is one-third of that at terminal 2. The shipping lead times t_s are randomly generated by $U(11,40)$, and unit shipping cost of each job equals $\frac{300}{t_s^2} * 10\% c_{ij}^{pro}$, which has positive relation with the production cost and negative relation with its shipping lead time.

d. The unit storage cost per day at the distribution center is 5% of the unit production cost.

SPP model

One separated production planning model would be also conducted so as to be compared with the integrated production planning model and demonstrate the significance of the integrated production planning with the multi-factory environment.

In SPP(separated production planning) model, the jobs are assigned to each factory according to theirs production cost. For instance, those comparatively most expensive jobs are first assigned to the factory with low production cost, and those inferior expensive ones left are assigned to the factory with high production cost. The production planning in one factory and its successive distribution scheduling are separated and independent from those for the other one.

Results and discussions

The result of the proposed integrated model and the comparison model (SPP) has turned out that, in general, the total cost obtained by the integrated model is lower than that of SPP by more than 14%. This indicated that job assignment based purely on production cost is not good enough for further production planning and distribution scheduling. The main contribution in reducing the total cost of the proposed integrated model comes from penalty cost. The penalty cost of the proposed model is 11% of the total cost which has reduced by 145% comparing with that of SPP, which is 24% of its total cost. This is because, for the SPP, jobs are assigned simply dependent on the difference of production costs between the factories without consider any other factors. In addition, production planning and distribution scheduling for each factory is considered separately as in the single-factory environment.

CONCLUSIONS

We have proposed an integrated scheduling model of production and distribution operations in a multi-factory manufacturing environment and a polynomial time exact algorithm by a modified MILP formulation. We conducted numerical experiments and investigated the value of integration by comparing it to a typical separated approach. Our numerical experiment shows that, in generally, significant improvement can be achieved by integration.

The time complexity of our algorithm is exponential in number of jobs. Future research is needed to answer the question of whether there exists a polynomial time heuristic with an arbitrary number of jobs. Alternative machine configurations like flowshop facilities are of interest. Alternative production-distribution objectives are also desirable for capturing more diverse applications.

Acknowledgements

REFERENCE

1. Chan, F. T. S., Prakash, A., Ma, H. L. and Wong, C. S. (2012), "A hybrid Tabu sample-sort simulated annealing approach for solving distributed scheduling problem", *International Journal of Production Research*, Vol. 51 No. 9, pp. 2602-2619.
2. Chen, Z.-L. (2010), "Integrated Production and Outbound Distribution Scheduling: Review and Extensions", *Operations Research*, Vol. 58 No. 1, pp. 130-148.
3. Chen, Z.-L. and Pundoor, G. (2006), "Order Assignment and Scheduling in a Supply Chain", *Operations Research*, Vol. 54 No. 3, pp. 555-572.
4. Chen, Z.-L. and Pundoor, G. (2009), "Integrated Order Scheduling and Packing", *Production and Operations Management*, Vol. 18 No. 6, pp. 672-692.
5. Chen, Z.-L. and Vairaktarakis, G. L. (2005), "Integrated Scheduling of Production and Distribution Operations", *Management Science*, Vol. 51 No. 4, pp. 614-628.
6. De Giovanni, L. and Pezzella, F. (2010), "An Improved Genetic Algorithm for the Distributed and Flexible Job-shop Scheduling problem", *European Journal of Operational Research*, Vol. 200 No. 2, pp. 395-408.
7. Garcia, J. M., Lozano, S. and Canca, D. (2004), "Coordinated scheduling of production and delivery from multiple plants", *Robotics and Computer-Integrated Manufacturing*, Vol. 20 No. 3, pp. 191-198.
8. Gnoni, M. G., Iavagnilio, R., Mossa, G., Mummolo, G. and Di Leva, A. (2003), "Production planning of a multi-site manufacturing system by hybrid modelling: A case study from the automotive industry", *International Journal of Production Economics*, Vol. 85 No. 2, pp. 251-262.
9. Hall, N. G., Lesaoana, M. and Potts, C. N. (2001), "Scheduling with Fixed Delivery Dates", *Operations Research*, Vol. 49 No. 1, pp. 134-144.

10. Li, C.-L., Vairaktarakis, G. and Lee, C.-Y. (2005), "Machine scheduling with deliveries to multiple customer locations", *European Journal of Operational Research*, Vol. 164 No. 1, pp. 39-51.

11. Stecke, K. E. and Zhao, X. (2007), "Production and Transportation Integration for a Make-to-Order Manufacturing Company with a Commit-to-Delivery Business Mode", *Manufacturing & Service Operations Management*, Vol. 9 No. 2, pp. 206-224.

12. Thoney, K. A., Hodgson, T. J., King, R. E., Taner, M. R. and Wilson, A. D. (2002), "Satisfying due-dates in large multi-factory supply chains", *IIE Transactions*, Vol. 34 No. 9, pp. 803-811.

13. Timpe, C. H. and Kallrath, J. (2000), "Optimal planning in large multi-site production networks", *European Journal of Operational Research*, Vol. 126 No. 2, pp. 422-435.

14. Wang, H. and Lee, C.-Y. (2005), "Production and transport logistics scheduling with two transport mode choices", *Naval Research Logistics (NRL)*, Vol. 52 No. 8, pp. 796-809.

ERP RESEARCH IN IS FIELD: A MULT-DIMENSIONAL REVIEW

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ABSTRACT

Purpose: The goal of this study is to gain a better understanding of the citation, publication, and productivity situations about ERP in the information systems (IS) field in the past from a multi-dimensional view.

Design: This study used 81 journals as data sources to analyze the number of citations and authorships of ERP articles. The time span of this study was from January 1997 to May 2012. We selected the articles by using the Web of Science (WOS) database, which resulted in a total of 674 records.

Findings: We reported the 14 most frequently cited articles and the number of citations, the ranking of authors, the key words, the distribution of academic institutions and their geographical locations. We also sorted out the rankings of journals and scholars based on the number of ERP articles published during the time span.

Originality/value: Most literature review studies in the past are insufficient to answer what journals or authors publish more ERP articles, what ERP articles are highly cited, and what future research directions of ERP are. This study answers these questions.

Keywords: ERP, Research Trend, WOS, Citation Analysis, Journal Ranking, Information Systems

A HYBRID GENETIC ALGORITHM FOR OPTIMIZING CUTTING PATHS OF OPEN AND/OR CLOSED CONTOURS

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ABSTRACT

The cutting path optimization problem concerned in this paper is to optimally determine a cutting sequence of parts nested on a stock plate in each of which a set of open and/or closed contours are enclosed. Each of the contours is assumed to have a finite set of vertices which are candidates for an entry point of cutting. Therefore, a cutting sequence of the contours on the stock plate and their entry points need to be determined simultaneously for the optimization problem such that the total non-productive traveling distance of a cutting torch is minimized. To solve the problem, a hybrid genetic algorithm is presented incorporating the r-Opt heuristic for achieving a local optimal sequence of parts and a dynamic programming algorithm to determine the optimal entry points of the contours. The computational results indicate the effectiveness and robustness of the hybrid genetic algorithm in that an exact optimal solution was always produced utilizing a shallow local search for the r-Opt heuristic.

Keywords: cutting path optimization; hybrid genetic algorithm; plate cutting; dynamic programming; open/closed contours

INTRODUCTION

These days, a large number of parts each enclosing a set of holes and irregularly shaped contours are arranged on a large thin plate and cut by a plate cutting machine equipped with a cutting torch sourced by either one of laser, oxyfuel flame, plasma, water jet, or electron beam. When cutting the parts, such machining operations as blanking, piercing, and engraving are dominantly carried out on the stock plate of various materials such as leather, rubber, textiles, plastics, wood, and sheet metals.

Because of the complexity in movements of the cutting torch, most of such cutting operations are inevitably done with the aid of a computer numerical control (CNC) machining system. In order to cut the parts through the CNC machine, NC part programs are necessary to guide and control torch

movements such that the torch should be either on the contour of the plate to cut it with a pre-specified speed or in the air to rapidly move on to other contour without cutting. The former movements of the torch are considered to be productive, whereas the 'air' time to move to neighboring parts after cutting the current one are non-productive, which should be minimized especially in mass production industry like ship building. To minimize the air time can be achieved by optimizing both the sequence of the contours and the choice of a starting point of cutting in each contour, which defines a cutting path optimization problem (COP). The starting point of cutting is called a 'piercing' or 'entry' point.

Manber and Israni(1984) presented a graph-theoretic approach to the cutter path problem of minimizing the number of piercing points in flame cutting. Jackson and Mittal(1993) addressed the automatic generation of NC programs from CAD data to cut a set of parts without considering optimization of cutter paths. Simulated annealing (SA) were adopted to develop cutting torch's path with minimum distance by Han and Na(1998), Khan et al.(1999), and Jang and Han(1999) allowing all the vertices of each contour to be piercing points. Chen and Zhong (2002) proposed a hybrid-coded GA (HCGA) to solve the COP with open or closed contours. In the HCGA, two chromosomes (CMSs) are hierarchically structured as the upper and lower ones representing the cutting sequence and entry points of contours, respectively. For the same HCGA, Wah et al.(2002) suggested an enhancement made by incorporating the 2-*Opt* and 3-*Opt* heuristics (Lin, 1965; Bentley, 1992) for local optimization for the COP with only open contours. Castellino et al.(2002) converted the COP into a standard TSP of double size by using the method of Dimitrijevic and Saric(1997), and then applied the sequential ordering problem heuristic (Ascheuer et al., 2000) and the Lin-Kernighan heuristic (Helsgaun, 2000) to the problems with and without precedence constraints, respectively. A micro-GA combined with a heuristic back-tracking method was proposed by Kim et al.(2004) to solve the COP with consideration of heat effect on the cutting-path sequence. Assuming that a piercing point is allowed to be located anywhere on each contour, Lee and Kwon(2006) developed a two-step GA to optimize both the cutting sequence and the location of piercing point for each contour. Qudeiri et al.(2007) presented a simple GA to determine optimal sequence of machining operations including drilling and pocketing that located in asymmetrical locations and different levels. Xie et al.(2009) applied GAs to optimize the sequences of laser cutting and punching independently.

Variants of the COP may be the continuous cutting path problems where cutting tools never leaves the cutting surface until every contours are cut. Most of the wire EDM cutting applications are well fitted to this continuous COP. A heuristic method for generating cutter path for thick and hard plates in an wire electro-discharge machine(EDM) was proposed by Imahori et al.(2008). Moreira et al.(2007) formulated the continuous COP as a variant of the rural postman problem and presented some heuristics. Recently, Rodrigues and Ferreira(2012) considered a similar problem and demonstrated the validity of the memetic algorithms developed by them with some computational results.

Most of the previous studies considered the COPs for stock plates where parts to be cut are simply represented by a single closed or open contour. Although there exist few works dealing with a more complex case of parts each being composed of closed inner contours (Han and Na, 1998; Jang and Han, 1999; Kim et al., 2004; Xie et al., 2009), realistic problems in which holes and inner contours of open and closed types are enclosed in each part have never been studied. In this paper, a new approach to the more general COP called the generalized COP (GCOP) is proposed to secure an optimal or near-optimal solution. The approach is based on a hybrid genetic algorithm (HGA) incorporating the *r-Opt* heuristic for the local optimality of contour sequence and a dynamic programming (DP) algorithm to determine the optimal piercing points each of which is restricted to be any one of corner points or vertices specified in each contour.

THE CUTTING PATH OPTIMIZATION PROBLEM

Problem Definition

A part to be cut on a plate is generally represented by an outer boundary contour and a set of inner contours including holes as a special case with a single vertex. Such contours are classified into two types, open ones and closed ones. Free formed curves, circular arcs, and open polygonal curves are examples of open contours, whereas any closed versions of them are closed contours as shown in Fig. 1.

When cutting open contours, any one of the two end vertices of the contour can be chosen as an entry point for the cutting tool, and then the other automatically becomes the exit point. On the other hand, approaching to and exiting from a closed contour occurs on a single point on the contour, and thus several vertices of the closed contour can be an alternative for the single entry/exit point. For example, any one of the nine vertices denoted by small gray circles in Fig. 1(right) can be used for the entry/exit point. Note that apart from the open contours, each of the closed contours can have a set of inner contours inside it.

A very comprehensive and generalized problem is obviously to cut a plate on which a set of parts each being comprised of a mixture of open and/or closed contours is nested. The GCOP is then to find a cutting path with the minimum total non-productive traveling distance by which starting from a single depot, the cutting tool moves to each of the contours to cut it and then returns back to the depot. In order to avoid thermal distortion and vibratory movements of the parts whose boundary contour has been cut already when their inner-contours are cut, precedence relationships among the contours are imposed upon the path such that all inner contours inside each part should be cut earlier than their part boundary. Therefore, to find the optimal cutting path, a cutting sequence of the contours and an entry point of each contour should be simultaneously determined, which makes the combinatorial problem very intractable to solve using any conventional optimization techniques. Fig. 2 illustrates such a

feasible cutting path represented as dashed directed lines for an example partial section of the GCOP consisting of two irregular parts each having four and three inner contours, respectively.
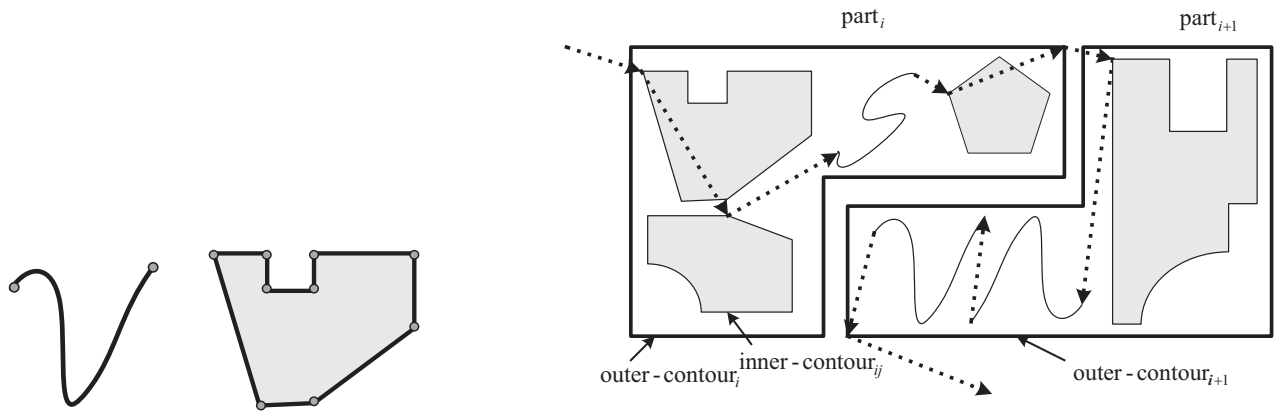
Fig. 1. Open(left) and closed(right) contours.

Fig. 2. An illustration of a cutting path for an example partial section of the cutting problem

A Dynamic Programming Algorithm for Entry-point Determination

In this section, a DP algorithm is presented to determine the optimal entry point of each contour when the contour sequence of cutting is given a priori. We use the following notation:

N_p = number of parts nested on the stock plate;

n_i = number of contours to be cut in part i including the outer–contour (i.e. the boundary of the part);

N_c = total number of outer- and inner-contours $(=\sum_{i=1}^{N_p} n_i)$;

C = a subset of the N_c contours, $C_0 = \{1, ..., N_c\}$; $m = |C|$;

nv_i = number of vertices specified for contour i;

W_i = set of vertices specified in contour i = $\{1, ..., nv_i\}$;

V = set of vertices each denoting entry point of a contour in $C = \{v_1, ..., v_m\}$ where $v_i \in W_i$; and

$V_0 = \{v_1, ..., v_{Nc}\}$.

For convenience' sake, let location 0 denote the depot. Let S_0 be the sequence of all the contours in C_0 specified by the directed chain constructed for C_0. Then the DP algorithm, $DP(V_0|S_0)$, to optimally solve for V_0 when S_0 is given is described in the following.

Let $g_m(v_{[m]})$ be the minimum nonproductive distance traveled to cut all the contours in C, following the given sequence, $S_0 = \{i_1, i_2, ..., i_{Nc}\}$, starting from the depot and ending at vertex $v_{[m]}$ of the m-th contour in the sequence. Then, the optimal entry point for each contour is determined by using the following recursive equation for $1 < m \le N_c$:

$$g_m(v_{[m]}) = \min_{v_{[m-1]} \in W_{[m-1]}} [g_{m-1}(v_{[m-1]}) + d(v_{[m-1]}, v_{[m]})] \text{ for all } m \text{ and } v_{[m]} \in W_{[m]}$$

where $d(v_y, v_x)$= non-productive distance traveling from vertex v_y of contour y to vertex v_x of contour x = M (a large real number) if the torch movement is prohibited by the precedence constraints. Especially if $m = 1$,

$$g_1(v_{[1]}) = d(v_0, v_{[1]}) \text{ for all } v_{[1]} \in W_{[1]} \tag{1}$$

where v_0 is the vertex indicating the center of the depot.

When $g_{N_c}(v_{[Nc]})$ has been recursively evaluated starting from equation (1), the minimum total nonproductive distance of a complete path including the depot will be

$$g^* = \min_{v_{[m]} \in W_{[m]}} [g_m(v_{[m]}) + d(v_{[m]}, v_0)].$$

Then, the optimal entry vertices, $V^* = \{j_1, j_2, ..., j_{N_c}\}$ can be obtained from the following equation for p ($1 \leq p \leq N_c-1$):

$$g_{p+1}(j_{p+1}) = g_p(j_p) + d(j_{p+1}, j_p).$$

The total number of evaluations for $g(\cdot)$ will be

$$\sum_{k=2}^{N_c} nv_{[k-1]} nv_{[k]} + nv_{[1]} + nv_{[N_c]}.$$

A HYBRID GENETIC ALGORITHM

To solve the GCOP concerned in this paper, decisions should be made on three issues, sequencing of parts (i.e., outer-contours), sequencing of inner-contours in each part, and determination of an entry point for each contour, which leads to the decomposition of the problem into three subproblems. They are respectively called here the part sequencing subproblem (SP1), the inner-contour sequencing subproblem (SP2), and the entry-point determination subproblem (SP3). Obviously, the three subproblems are not independent, and thus they should be solved in a hierarchically integrated manner.

The GA developed in this paper is hybrid in that based on a canonical (or standard) GA (Gen and Cheng, 2000), the *r-Opt* search heuristic (Lin, 1965; Bentley, 1992; Freisleben and Merz, 1996) and $DP(S_0|V_0)$ are employed to expedite the investigation of a global optimal solution. In the following, features of the standard GA which is specifically tailored only for the SP1 is first described and followed by the *r-Opt* heuristic employed for the SP1 and the SP2 and the overall procedure of the proposed HGA. Fig. 3 shows an illustration of the solution structure of the GCOP, related subproblems, and the algorithms to solve them.

Item	Solution Structure						Problem	Algorithm
Part (*CMS*)	7	2	...	3	...	9	SP1	GA + *r-Opt*
Inner-Contour		6 5	...	1	... 8		SP2	*r-Opt*
Entry Point		3 2	...	4	... 7		SP3	$DP(O_0|S_0)$
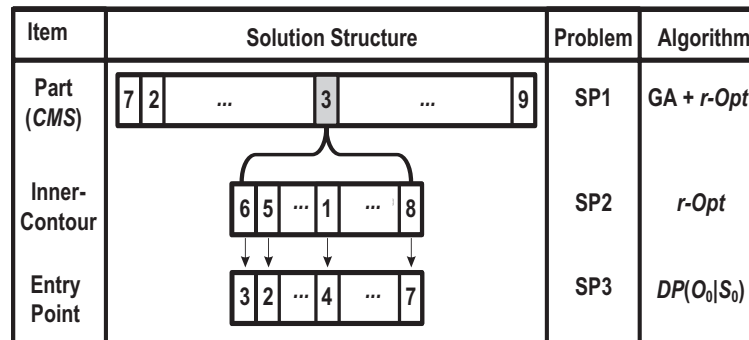
Fig. 3. The solution structure, related sub-problems, and their algorithms for the HGA.

Features of the standard GA

Chromosome representation

A solution of the GCOP is composed of the sequence of outer- and inner-contours and their entry points. For the standard GA for the SP1, only the sequence of outer-contours in the form of a permutation of $[1, \ldots, N_p]$ is represented as a chromosome. Therefore, a natural number ranged from 1 to N_p is assigned to each gene in the chromosome such that all the assigned numbers are different each other.

Fitness function

The fitness function of a chromosome should reflect the degree of possibility for being survivable in the next population. Since we want to minimize the total nonproductive distance of chromosome i, npd_i, taken to cut all the contours whose sequence is specified in the chromosome, and the fitness value denoted by f_i is ensured to be bounded, it is simply defined here as

$$f_i = 1/(1+ npd_i). \tag{2}$$

Selection policy

In this paper, we use the well-known roulette wheel selection policy by which a pair of chromosomes is chosen according to their relative fitness values. The relative fitness value of a chromosome is its fitness value divided by the total fitness value of all the chromosomes included in the population. This selection policy will ensure that the characteristics of chromosomes with higher fitness values will be passed onto the next generation with higher probability. Also adopted is the *elitist* strategy by which the best chromosome in the current population is always copied to the next generation.

Generally, the next population is composed of offspring directly transferred from the previous population and those newly generated by crossover and mutation operations. In this paper, we set the portion of the offspring copied from the previous population without any alteration equal to α.

Genetic operators

   Usually, offspring are reproduced first by crossover operation, and then mutation is applied to provide a diversity of search space. In this paper, the order crossover (OX) presented by Davis (1985) is used to reproduce offspring. For a pair of cut points selected randomly, the order crossover combines two parental gene strings by keeping the substring between the cut points and adding the missing genes in the order they appear in the other parent. For mutation operation, a simple mutation operator called the inversion which exchanges the locations of two strings at random is used.

The r-Opt heuristic

   A path of contours is defined to be *r-Opt* if no improvement in the total nonproductive distance can be expected by replacing any *r* of its links (or edges) with any other link set of the same size (Lin, 1965). The *r-Opt* heuristic and its refinements such as the Lin-Kernighan heuristic (Lin and Kernighan, 1973) have been frequently applied to a variety of permutation problems (Bentley, 1992; Freisleben and Merz, 1996; Bonny and Henkel, 2006). Basically, for the application of the *r-Opt* heuristic, distances between any two contours are assumed to be fixed and symmetric. Note that based on this assumption, the quality improvement being made from a new replacement is easily measured in standard symmetric TSPs by calculating the gain in the total nonproductive distance only for replaced links. Unfortunately however, this is not always the case with the GCOP due to the existence of alternative entry points for each contour, and therefore the *r-Opt* heuristic cannot be directly applied.

   Now, suppose that we have a solution of the GCOP. Then, a replacement of any *r* contour links generates a new sequence of contours whose entry points are exactly the same as the old one, and thus they may be not optimal any more for the new one. It should be noted here that any change in the sequence of contours will definitely affect the configuration of their optimal entry points in the whole sequence. Therefore, for each possible replacement of *r* links, in order to examine its acceptability as an improved solution, new optimal entry points for all the contours should be determined. As is described previously, this can be done by the DP algorithm, $DP(V_0|S_0)$.

Procedure of the proposed algorithm

   The skeleton of the HGA is the standard GA to search for an optimal part sequence into which the *r-Opt* heuristic and $DP(V_0|S_0)$ are incorporated to improve the sequence of inner- and outer-contours and to optimally determine their entry points for a given contour sequence, respectively.

   A sequence of all the parts is represented as a chromosome which will serve as an initial solution of the SP1 as illustrated in Fig. 3. $(1-\alpha)N_p$ chromosomes in each population are newly generated by genetic operations of crossover and mutation, while the remaining αN_p chromosomes are directly copied from the top ranked chromosomes in the previous population. Mutation is applied to the

chromosomes made by the crossover operation at a rate of β. Whenever a new chromosome is reproduced from the genetic operations, the *r-Opt* heuristic for parts is then used to convert it into an improved one having a local optimal fitness value. Such a conversion problem is denoted above by the SP1.

Now suppose that an improvement can be realized from a new sequence of parts made from a replacement of *r* links while inner-contour sequence remains unchanged, but the entry points for all the contours are optimized with the new part sequence. Then, the new sequence becomes a basis from which improvements on the inner-contour sequence will be continuously made until a local optimum is achieved by using the *r-Opt* heuristic for inner contours. Note that the problem to determine an optimal sequence of inner-contours given a part sequence is defined as the SP2.

For each replacement trial of any *r* part (or inner-contour) links, its contribution in terms of nonproductive distance should be evaluated, which necessitates determining the optimal entry points of all the contours beforehand. Such an entry point determination problem is denoted above by the SP3 which can be solve optimally by using $DP(V_0|S_0)$.

When the SP2 has been solved through an exhaustive search for lucrative link-replacement trials of inner-contours, the resulting fitness value and inner-contour sequence are saved for the current part sequence. Then a new part sequence is generated from the current one by the link replacement and undergoes the test of improvement. This process is repeated until no further improvement from any part-link replacement is expected, which implies that the SP1 has been solved with the *r-Opt* solution. Then, the final part sequence becomes the gene values of the chromosome at hand with its fitness value computed from equation (2) by using the total nonproductive distance of the *r-Opt* solution. Finally, when offspring for a new population are all generated, they are sorted in decreasing order of fitness value.

Now let t = generation index ($\leq T$), $P(t)$ = population t, and $C(t)$ = offspring generated from $P(t$-1) at t. Then, the HGA is stated in an algorithmic form as follows:

Set t =0; Initialize $P(t)$;
Apply the *r-Opt* heuristic to each chromosome in $P(t)$;
Sort all chromosomes in $P(t)$ in decreasing order of fitness value;
while ($t \leq T$) **do**
begin
$t = t$+1; $C(t) = P(t) = \varnothing$;
Pass top $(1-\alpha)N_p$ chromosomes in $P(t$-1) on to $P(t)$;
Reproduce αN_p offspring by crossover and add them to $C(t)$;
Modify $\alpha\beta N_p$ offspring in $C(t)$ by mutation;
Apply the *r-Opt* heuristic to each chromosome in $C(t)$;
Add $C(t)$ to $P(t)$;
Sort all chromosomes in $P(t)$.
end

COMPUTATIONAL RESULTS

In this section, the performance of the HGA is examined for a hypothetically generated problem. The problem is specially structured such that their optimal solutions can be readily identified by intuition. Fig. 4 shows the problem where a total of 132 contours are arranged along the side lines of a rectangle and the optimal path cutting all the contours is given by dotted lines.

The *r-Opt* heuristic can be actually implemented in various ways. For the 2-*Opt* heuristic, we use the conventional type of link replacement which is to remove any two links in the present path and replace them with two other links. In case of the 3-*Opt* heuristic, we adopt the *fast*-3-*Opt* (Bentley, 1992) which can be suitably implemented as local search procedure for asymmetric TSPs due to its maintainability of tour fragment direction. Through the *fast*-3-*Opt* heuristic, a tour fragment of contours is taken randomly and then reinserted at another position without reversing the order in which the contours are cut. For the SP1 and the SP2, the 2-*Opt* heuristic is first applied and followed by the *fast*-3-*Opt* heuristic.

For the *r-Opt* heuristic, stopping criteria such as a time limit of performing the replacement or a maximum number of replacement times need to be established. For the computer experiments made in this study, the time limit of 600sec was used as a stopping criterion. For the following description of

computational results, let NR_p and NR_{ic} denote the numbers of replacement times for part and inner-contour sequencing, respectively.

A computer program to implement the HGA was written by using the C programming language and run on a personal computer, Pentium IV with 2.0GB RAM based on 3.0GHz Intel CPU.
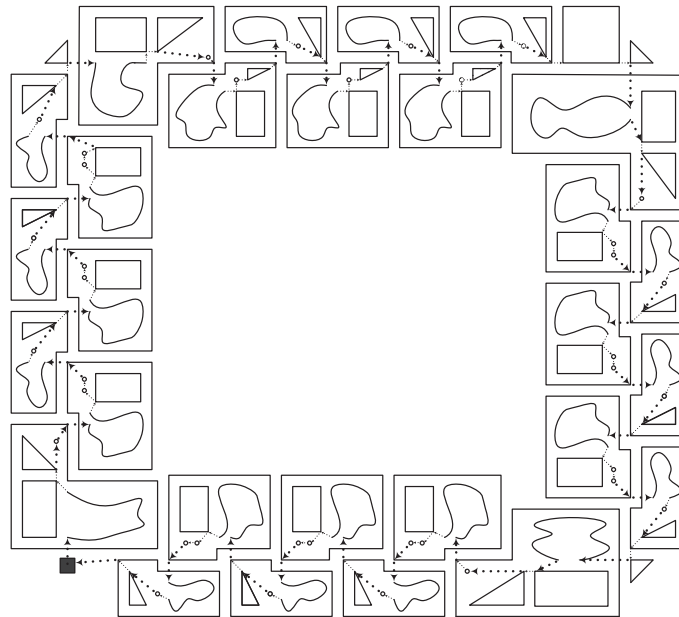
Fig. 4. A test 'root' problem whose optimal cutting path is known.

Test for the validity of the hybrid GA

The HGA was applied to solving the generated problem. Due to the stochastic nature of genetic algorithms, the proposed algorithm may produce different solutions to the same problem. To take this into account, a total of 100 runs each with a different initial population were carried out. Since the optimal solution of the generated problem is known, the computer program was set to be terminated whenever the optimal solution is reached or the total execution time exceeds the time limit of 600s.

Table 1 summarizes the average computational results obtained with $NR_p = 500$ and $NR_{ic} = 10$. The success probability of achieving the respective optimal solution was 1.0, which shows that the HGA generated the optimal solution in every run, and therefore the average nonproductive distance turned out to be exactly equal to its respective optimum. It follows from the computational results that the proposed HGA is very robust and effective in that an optimal solution can be produced for the problem without any exception.

The average number of total generations required to yield the optimal solution is less than 10, which shows the HGA solution converges in a few generations for most of the time. Obviously, as the problem size increases, so do the computation time and the number of total generations needed to get the optimum.

When optimal solutions for test problems are known, the effectiveness of an algorithm can be evaluated by the percent deviation, D, of the total non-productive distance of a solution from its optimal value. Fig. 5 shows the best and average percent deviations of the proposed HGA against the number of generations. A dramatic decrease in deviation for the first few generations followed by a convergence to the optimum is observed from the Figure, which at least partially indicates the validity of the proposed HGA.
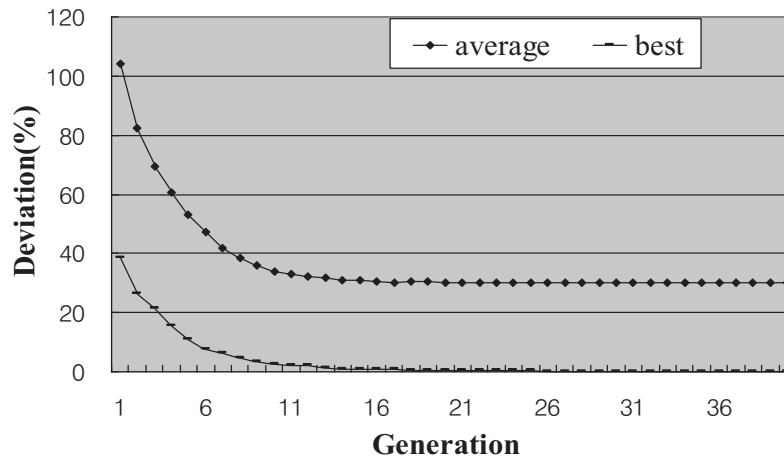
Fig. 5. The best and average relative effectiveness of the proposed HGA against the number of generations.

Effect of the number of replacement times in the r-Opt heuristic

The exhaustive search for the advantageous replacement of r links definitely guarantees an *r-Opt* solution, but may deter the convergence of the HGA solution. In this experiment, a trade-off relationship between the depth of local search and the convergence speed of the HGA is investigated. It was conjectured that there would be a favorable region for the number of replacement times yielding the best results in terms of algorithm efficiency while guaranteeing the optimum.

Performance variation against the number of link-replacement times, NR_p, (while NR_{ic} is set to be 10) is listed in Table 2. Note that the case where NR_p is 0 implies the standard GA without the *r-Opt* heuristic and is considered here for comparison purpose. As is obviously expected, the total number of

generations sharply decreases as the number of the link-replacement times increases due to the higher availability of local solutions matured fast by the deeper local search. In contrast to this, the computation time required to reach the optimal solution appears to follow a convex curve showing the initial plummet and then slow increase because of the additional computation burden needed for over-matured local search. Also, as searching for the local optimality becomes intensified, the success probability of generating the optimal solution sharply increases up to one. Therefore, as conjectured in the beginning, some favorable region of the number of link-replacement times was identified as somewhere around NR_p=500. From this result, it is observed that the exact r-Opt solution is not always necessary for the evaluation of a chromosome, and instead near- or even away-from-optimal solution obtained from the r-Opt heuristic may be more fruitful for the global efficiency.

Finally, the performance of the standard GA turned out to be very inferior to the HGA, but even a slight utilization of the r-Opt heuristic with shallow local search leads to the optimal cutting path without fail, which definitely justifies the incorporation of the r-Opt heuristic into the HGA.

Table 1. Average computational results.

Total Number of Generations	CPU Time (s.)	Optimal Nonproductive Distance	Obtained Nonproductive Distance	Success Prob.
9.161	46.635	483.735	483.735	1.0

Table 2. Performance variation of the HGA against the number of link-replacement times.

NR_p	Total Number of Generations	CPU Time (s.)	Obtained Nonproductive Distance	Success Prob.
0	2740.150	544.805	628.910	0.18
10	734.317	133.383	500.005	0.93
100	66.790	63.219	483.735	1.00
500	9.161	46.635	483.735	1.00
1000	3.852	47.579	483.735	1.00
2000	1.414	55.037	483.735	1.00

CONCLUSIONS

This paper deals with the problem of generating an optimal cutting path of a traveling torch for a stock plate nested with a set of parts in each of which open and/or closed contours are to be cut. To solve the problem, a hybrid genetic algorithm incorporating the r-Opt heuristic for the local

optimization of part/contour sequencing and the DP algorithm for contour entry-point determination is proposed. It can be observed from the computational results as follows:

- The HGA produces an exact optimal solution in every run with an adequate depth of search for the *r-Opt* heuristic;
- A full depth of local search is not needed for the *r-Opt* heuristic, and thus an improvement in the efficiency of the HGA can be achieved.

These observations are believed to back up the effectiveness and robustness of the proposed algorithm. Since the problem treated in this paper is very comprehensive, the proposed algorithm can be broadly applied to a variety of CNC based cutting processes such as laser, flame, plasma, electron beam, and water-jet machining.

REFERENCES

1. Ascheuer, N., Jünger, M., and Reinelt, G. (2000), "A branch & cut algorithm for the asymmetric traveling salesman problem with precedence constraints", *Computational Optimization and Applications*, Vol. 17 No. 1, pp. 61-84.
2. Bentley, J. L. (1992), "Fast algorithms for geometric traveling salesman problems", *ORSA Journal on Computing*, Vol. 4 No. 4, pp. 387-411.
3. Bonny, T. and Henkel, J. (2006), "Using Lin-Kernighan algorithm for look-up table compression to improve code density", *Proceedings of the 16th ACM Great Lakes Symposium on VLSI*, pp. 259-265.
4. Castelino, K., D'Souza, R., and Wright, P. K. (2002), "Tool path optimization for minimizing airtime during machining", *Journal of Manufacturing Systems*, Vol. 22 No. 3, pp. 173-180.
5. Chen, J. C. and Zhong, T. X. (2002), "A hybrid-coded genetic algorithm based optimization of non-productive paths in CNC machining", *Int. J. of Advanced Manufacturing Technology*, Vol. 20 No. 3, pp.163-168.
6. Davis, L. (1985), "Applying adaptive algorithms to epistatic domains", in *Proceedings of the International Joint Conference on Artificial Intelligence*, pp. 162-164.
7. Dimitrijevic, V. and Saric, Z. (1997), "An efficient transformation of the generalized traveling salesman problem into the traveling salesman problem on diagraphs", *Information Science*, Vol. 102, No. 1-4, pp. 105-110.
8. Freisleben, B. and Merz, P. (1996), "A genetic local search algorithm for solving symmetric and asymmetric traveling salesman problems", in *Proceedings of IEEE Int'l Conference on EVol.utionary Computation*, pp. 616-621.
9. Gen, M. and Cheng, R. (2000), *Genetic algorithms and engineering optimization*, John Wiley & Sons, New York, NY.

10. Han, G. and Na, S. (1998), "Global torch path generation for 2-D laser cutting process using simulated annealing", *Intelligent Automation and Soft Computing*, Vol. 4 No. 2, pp. 97-108.

11. Helsgaun, K. (2000), "An effective implementation of the Lin-Kernighan traveling salesman heuristic", *European Journal of Operational Research*, Vol. 126 No. 1, pp. 106-130.

12. Imahori, S., Kushia, M., Nakashima, T., and Sugihara, K. (2008), "Generation of cutter paths for hard material in wire EDM", *Journal of Materials Processing Technology*, Vol. 206 No. 1, pp. 310-325.

13. Jackson, S. D. and Mittal, R. O. (1993), "Automatic generation of 2-axis laser cutter NC machine program and path planning from CAD", *Computers in Industry*, Vol. 21 No. 2, pp. 223-231.

14. Jang, C. D. and Han, Y. K. (1999), "An approach to efficient nesting and cutting path optimization of irregular shapes", *Journal of Ship Production*, Vol. 15 No. 3, pp. 129-135.

15. Khan, W. A., Hayhurst, D. R,, and Cannings, C. (1999), "Determination of optimal path under approach and exit constraints", *European Journal of Operational Research*, Vol. 117 No. 2, pp. 310-325.

16. Kim, Y., Gotoh, K., and Toyosada, M. (2004), "Global cutting-path optimization considering the minimum heat effect with microgenetic algorithm", *Journal of Marine Science and Technology*, Vol. 9 No. 2, pp. 70-79.

17. Lee, M.-K. and Kwon, K.-B. (2006), "Cutting path optimization in CNC cutting processes using a two-step genetic algorithm", *International Journal of Production Research*, Vol. 4 No. 24, pp. 5307-5326.

18. Lin, S. (1965), "Computer solutions of the traveling salesman problem", *Bell System Technical Journal*, Vol. 44, No. 10, pp. 2245-2269.

19. Lin. S., Kernighan, B. (1973), "An effective heuristic algorithm for the traveling salesman problem", *Operations Research*, Vol. 21 No. 2, pp. 498-516.

20. Manber, U. and Israni, S. (1984), "Pierce point minimization and optimal torch path determination in flame cutting", *J. of Manufacturing Systems*, Vol. 3 No. 1, pp. 81-99.

21. Park, S. C. and Choi, B. K. (2000), "Tool-path planning for direction-parallel area milling", *Computer-Aided Design*, Vol. 32 No. 1, pp. 17-25.

22. Qudeiri, J. A., Yamamoto, H., and Ramli, R. (2007), "Optimization of operation sequence in CNC machine tools using genetic algorithm", *Journal of Advanced Mechanical Design, Systems, and Manufacturing*, Vol. 1 No. 2, pp. 272-282.

23. Rodrigues, A. M., and Ferreira, J. S. (2012), "Cutting path as a rural postman problem: solutions by memetic algorithms", *International Journal of Combinatorial Optimization Problems and Informatics*, Vol. 3 No. 1, pp. 22-37.

24. Sardinas, R. Q., Santana, M. R., and Brindis, E. A. (2006), "Genetic algorithm-based multi-objective optimization of cutting parameters in turning processes", *Engineering Applications of Artificial Intelligence*, Vol. 19 No. 2, pp. 127-133.

25. Wah, P. K., Murty, K. G., Joneja, A., and Chiu, L. C. (2002), "Tool path optimization in layered manufacturing", *IIE Transactions*, Vol. 34, pp. 335-347.

26. Xie, S. Q., Gan, J, and Wang, G. G. (2012), "Optimal process planning for compound laser cutting and punching using genetic algorithms", *International Journal of Mechatronics and Manufacturing systems*, Vol. 2 No. 1/2, pp. 20-38.

A NOVEL FREQUENCY-BASED FORECASTING MODEL FOR FUZZY TIME SERIES

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ABSTRACT

In our daily life, people often used forecasting techniques to predict weather, stock, economy and even some important KPI like GDP, CPI, exchange rate, and so forth. Therefore, forecasting method has recently received increasing attention. The ability of forecasting precisely can help policy maker to make appropriate decision or strategy to deal with variation in the future.

In recent years, there are many researchers using fuzzy time series method to forecast because of its capability of dealing with vague data. But the traditional fuzzy time series forecasting method ignored the frequency of fuzzy transactions. Therefore the influence of some forecasting rules which are seldom happened will be more serious and cause inaccurate estimated result.

In this paper, we present a fuzzy frequency-based forecasting model which is enhanced from the traditional fuzzy time series forecasting sequence. Beside, we consider the impact of frequency in building fuzzy relation and wish this proposed model to forecast more precisely.

Keywords: Fuzzy Time Series, Frequency-Based, Forecast

INTRODUCTION

In the information explosion era, forecasting is a useful methodology for enterprises or government to predict future trends and make a decision. The accurate forecasting ability will help managers to make appropriate decisions to match the changeable situation and decrease the probability of making wrong judgment.

With the purpose of forecasting precisely, the methodology of time series has been studied for a long time and applied in a great variety of areas, such as monitoring air pollution, predicting stock prices, estimating rainfall and even foreseeing some important KPIs like GDP, CPI, exchange rate, and so forth.

Different time series approaches have been proposed, including traditional and fuzzy methods. Fuzzy method, which is aim to deal with vague and ambiguous data type, is different from the traditional method. Traditional time series forecasting, such as statistics and neural networks, is dependent on historical data, which may be imprecise and ambiguous.

Furthermore, some of the data sources contain crisp information, but others that are vague and ambiguous are unable to express data in a precise manner, such as stock monitoring indicators, signals, and so on. For example, the questionnaires commonly have questions with scaled responses that are written using technical jargon. These types of data cannot be analyzed using traditional times series techniques. Thanks to Zadeh (1965) who proposed the fuzzy theory, vague but useful data can now begin being analyzed to make appropriate decisions.

Based on the fuzzy theory, Song and Chissom (1993) first proposed the fuzzy time series to deal with cases that consist of vague data in time series, and proposed seven steps for forecasting. Moreover, they divided problems into time invariant and time variant. The overall contribution proposed by Song and Chissom is the basis for our study of the fuzzy time series today.

The seven steps proposed by Song & Chissom (1993) are：(1) Define the universe of discourse; (2) partition the universe into several intervals; (3) define fuzzy sets on the universe; (4) fuzzify the historical data; (5) establish fuzzy relations; (6) calculate the forecasted outputs; (7) defuzzification. The literature used Alabama university enrollments data to carry out one factor time relational, invariant fuzzy time series forecast model. Sullivan and Woodall (1994) used seven steps proposed by Song & Chissom (1993) and improved the results by using Markov's matrix based probability statistics method to establish one-factor one-order time invariant fuzzy time series forecast model.

Due to the complexity of computing the FLR matrix, Shyi Ming Chen (1996) proposed fuzzy logical relationship group (FLRG) combined with the simple arithmetic operators to reduce the complexity. Hwang, Chen, and Lee (1998) further extended the time- variant method by incorporating the criterion and operation matrix into the time-variant method to highlight the importance of the last timestamp. Shyi Ming Chen (2002) extended his previous work, Shyi Ming Chen (1996), into high order fuzzy logical relationship group. However, the repeated rules were viewed as useless and deleted until Yu (2005) proposed weighted fuzzy time series. Yu

(2005) thought that the repeated rules still played an important role in providing a different weight according to chronological order to forecast TAIEX.

All the above introduced methods ignored the influence of rule frequency. Therefore, some rules, which don't occur often, still impact the estimated result seriously. Wishing to deal with such problem, this study proposed a new method to catch an appropriate weight for rules to forecast improved results.

UNDERLYING THEORIES AND TECHNIQUES

In this section, we briefly review the theories and techniques that are related to this research.

A. Fuzzy Time Series

Although there are many statistical methods that can be used to solve the problem of time series, it is impossible to resolve this problem when the historical data is of linguistic value. It wasn't until 1993, when Song and Chissom first proposed the fuzzy time series, that a resolution to this problem was found. Because of its easiness to use and comprehend, there are many scholars who have dedicated their time and energy to the field of fuzzy time series making it more complete and accurate.

Song and Chissom (1993) first proposed a complete fuzzy time series forecasting model and divided it into 7 steps. Nevertheless, there are still many details worthy of further exploration on this architecture. Therefore, many scholars have continuously revised this framework in order to get better forecasting accuracy. The seven steps are: (1) defining universe of discourse, (2) partitioning into several intervals, (3) defining fuzzy sets and linguistic values, (4) fuzzifying historical data, (5) building up fuzzy relation, (6)linguistic forecasting, and (7)defuzzification.

Sullivan and Woodall (1994) later proposed a discrete Markov model for establishing the fuzzy relationships matrix determined by the probability distributions of linguistic values. Chen (1996) used first-order fuzzy logic relationship groups and a simple arithmetic method to reduce the complexity of matrix computation. S.-M. Chen and Hwang (2000) extended fuzzy time series to multi-factor problems, and proposed a two-factor first-order time variant forecasting algorithm. Huarng (2001) then enhanced the model of Chen (1996) by integrating domain-specific heuristic knowledge to establish a high-order time-invariant fuzzy time series forecasting model. Chen (2002) improved his previous work by establishing one-factor high-order forecasting model; from then on, high-order models had subsequently received more attention. Based on Chen (2002)model, Own & Yu (2005) integrated the concept of fuzzy logic relationship and domain-specific heuristic knowledge to build up a trend heuristic fuzzy time series. Chen & Chung (2006) used genetic algorithm in interval partition steps in order to get better partitioning points and showed a better forecasting result as well. Lee, Wang, Chen, and Leu (2006) extended the

Proceedings of 2014 International Conference on
Technology Innovation and Industrial Management
28th-30th May 2014, Seoul, South Korea

model of Chen (2002) and proposed two-factor high-order time invariant fuzzy time series. Li and Cheng (2007) proposed a deterministic fuzzy time series model which used a backtracking algorithm to build up fuzzy logic relationship at one time to deal with high-order problems which need to find better FLR length result iteratively. Li and Cheng (2010) later enhanced their model to extend one-factor to two-factor high-order time-invariant fuzzy time series and a probabilistic smoothing hidden Markov model. Fuzzy time series are getting more attention because of good performance in handling vague data.

B. Fuzzification

If the historical data is not ambiguous, we need to fuzzify it first, for example, hot, cold and linguistic values. The process of fuzzification usually uses triangular fuzzy sets. The triangular fuzzy set of equal length intervals is represented in figure 1, the unequal length intervals are represented in figure 2.
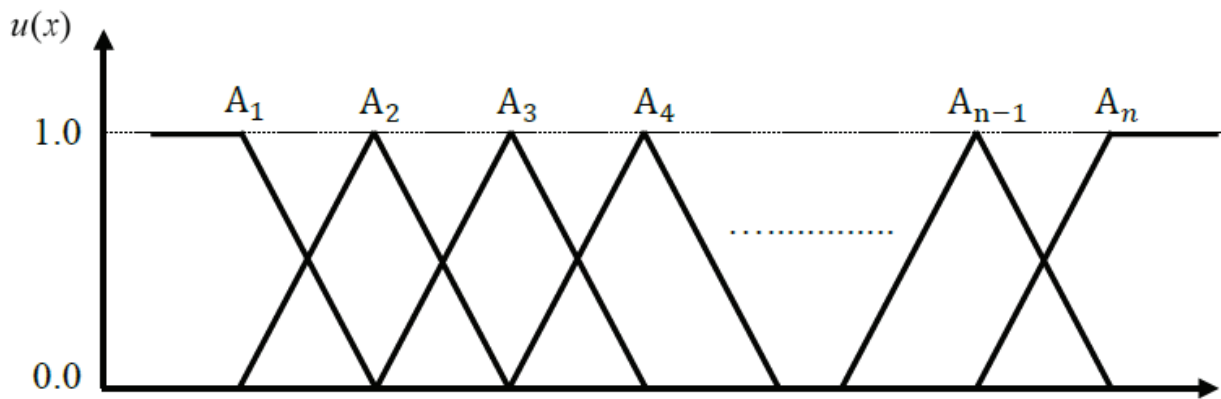
Figure 1 Linguistic values and triangular fuzzy set of equal length intervals
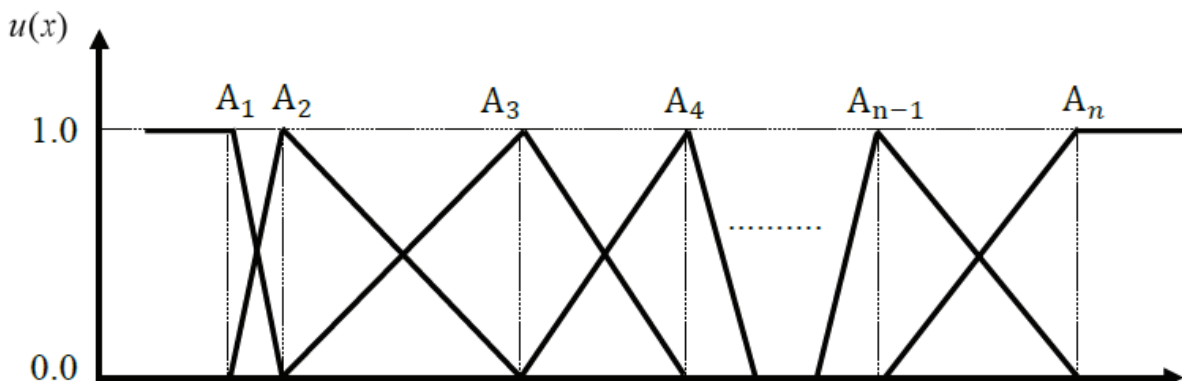
Figure 2 Linguistic values and triangular fuzzy set of unequal length intervals

C. Establish Fuzzy Relation

Building up fuzzy relation is the most important part in the fuzzy time series forecasting model, therefore, there are numerous scholars that have this objective in mind. Among many scholars, Song and Chissom proposed the time-variant and time-invariant fuzzy relation matrix, and Shyi Ming Chen (1996) proposed fuzzy logical relationship in combination with a simple arithmetic operation. Both of these methods are well-known and widely used for upcoming study.

Let's introduce Song and Chissom's method. First, we need to observe the fuzzy relation R_j historical data. Second, find the relation matrix R which is composed of R_j. Using following equation, we can get the relation matrix R, where R_j comes from the first step and N means the total number of fuzzy relations.

$$R = \bigcup_{J=1}^{N} R_J$$

Finally, we can establish a forecasting model. There are many models for forecasting models and the following formula is one of compositions to forecast data, where " ° " is the max-min operator.

$$A_i = A_{i-1} \circ R$$

Then we can get the forecasting result.

MODEL

In this section, we present the fuzzy frequency forecasting model based on fuzzy time series. The proposed method consisting of seven major steps has the same sequence as that of traditional fuzzy time series forecasting method, but the proposed method is novel in fuzzy relation matrix and forecasting method.

1. Define Universe of Discourse U

Here we follow the traditional method that Song & Chissom (1993) defined the universe of discourse U as follows:

$$U = [D_{min} - D_1, \quad D_{max} + D_2]$$

where D_{min} and D_{max} are the minimum and the maximum in the training date set, D_1 and D_2 are the two proper positive integers decided by the analyst.

2. Partition the universe of discourse

The interval partitioning approaches can be classified into two categories: equal length interval and unequal length interval.

We also follow the traditional technique, equal length interval, to partition the universe of discourse. Therefore, we can compare with other model without any other impact. Huarng (2001) proposed two equal length interval methods, namely distribution-based length and average-based length.

- Distribution-based Length

(1) Compute the differences of two continuous values of data and average.

(2) Based on table 2.6, find the base of interval length.

(3) Plot the cumulative distribution of the first differences. The base determined in step 2 is used as intervals.

(4) According to the base determined in step 2, choose as the length of intervals the largest length that is smaller than at least half the first differences.

- Average-based Length

(1) Compute the difference of two continuous values between data and average.

(2) Take half of the average as the length.

(3) Based on table 1, find the base of the interval length.

(4) Round the length according to the determined base as the length of intervals.

Table 1 Base mapping table

Range	Base
0.1-1.0	0.1
1.1-10	1
11-100	10
101-1000	100

3. Define Fuzzy Set and Linguistic Values

After fuzzyfying historical data, we then begin to decide linguistic values. Each interval must have its own fuzzy membership and linguistic term. Then we will match each time series data with all fuzzy membership to get several fuzzy numbers that belong to corresponding linguistic terms.

4. Fuzzify Historical Data

If the historical data is not ambiguous, we need to fuzzify it first, for example, hot, cold and linguistic values. The process of fuzzification usually uses triangular fuzzy sets.

As we have mentioned in step 3, we will match each time series data with all fuzzy membership to get several fuzzy numbers. Therefore each time series data will have fuzzy numbers used to describe how the data belong to corresponding linguistic terms. In other words, the fuzzy number is the degree of data belonging to corresponding linguistic terms. Then the maximal fuzzy number is the best linguistic term to describe that data.

5. Establish Fuzzy Relation

This step is the most important part of our proposed model. To overcome the problem of disregarding the meaning of rule frequency, this model suggests a new technique to develop fuzzy relation. There is an announcement that our model is based on one-factor one-order forecasting sequence, therefore, it is easy and efficient.

After fuzzyifing the time series data, the fuzzy time series data with time T will be displayed as following:

$$A_0, \quad A_1, \dots, A_{T-1},$$

Each transformation between data is a rule, then we can calculate the frequency of rule to get fuzzy relation matrix. Because of the number inside the matrix is counting on frequency, the number may be bigger than one. We need to transform the matrix by dividing with the biggest value of that row; therefore, the biggest number of each row may be one, which means the possibility of the rule will be matched. It makes sense for fuzzy relation matrix

$$R = \begin{bmatrix} r_{11} & \cdots & r_{1n} \\ \vdots & \ddots & \vdots \\ r_{n1} & \cdots & r_{nn} \end{bmatrix}$$

6. Forecasting

After establishing fuzzy relation matrix or fuzzy logical relationship, we begin to forecast linguistic value and then defuzzify it into a precise one.

Here we also introduce Song and Chissom's method for forecasting. As we have mentioned previously, the forecasting model is as the following formula, where " ° " is the max-min operator.

$$A_i = A_{i-1} \circ R$$

Then every data may have a forecasting value for each membership, the biggest value presents the forecasting fuzzy result.

7. Defuzzification

After all previous steps, we have the forecasting results with fuzzy values. We ought to defuzzify the ambiguous values into precise estimated outcomes. We conduct fuzzy mean method to defuzzify the fuzzy result, which is expressed as:

$$FM(C) = \frac{\sum_{i=1}^{N} \mu_i C_i}{\sum_{i=1}^{N} \mu_i}$$

N : the amount of fuzzy set;

μ_i : the ith membership degree;

C_i : the ith midpoint of interval corresponding to the ith linguistic value

The influence of rule frequency may be accompanied with this difuzzification to get more precise results.

EXPERIMENTS AND ANALYSIS

This section demonstrates the application of the proposed method and compares the accuracy of its forecasted results with those obtained by other methods. In order to evaluate the superiority of the proposed model, we use two evaluation indices to evaluate the performance, namely mean square error (MSE) and percent mean absolute deviation (PMAD).

(1) MSE (Mean Square Error)

$$MSE = \frac{\sum_{i=1}^{n} (\hat{x}_i - x_i)^2}{n}$$

(2) PMAD (Percent Mean Absolute Deviation)

$$PMAD = , \frac{\sum_{i=1}^{n} |\hat{x}_i - x_i|}{\sum_{i=1}^{n} |x_1|}$$

,
where $\hat{x}_i$ is the forecasted value, x_i is the actual value and n is the number of forecasted values.
A. Alabama University annual enrollment data

Here we adopt the well-known data, Alabama University annual enrollment, which is often used in fuzzy time series forecasting area. Alabama University annual enrollment data have been accumulated for 22 years from 1971 to 1992.

Tracking the step of the proposed model, the fuzzy relation matrix is displayed as follows:

$$R = \begin{bmatrix} 1 & 0.5 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0.286 & 0 & 0 & 0 \\ 0 & 0 & 0.5 & 1 & 0 & 0.5 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 & 1 \end{bmatrix}$$

Conducting the rest steps, we will get the forecasting result and then compare with other models. Here we compare our outcome with three other models applying Alabama University annual enrollment data, too. Those models are all using one-factor one-order fuzzy time series forecasting method; therefore, the only difference between models is the technique to contract fuzzy relation. We compute MSE and PMAD for each model and show as the following table 2.

Table 2 The comparison of various one-factor one-order models

Year	Enrollment	Song&Chissom (1993)	Sullivan&Woodall (1994)	Chen (1996)	Proposed Model
1971	13055				
1972	13563	14000	13500	14000	13833
1972	13847	14000	14500	14000	13917
1974	14696	1400	14500	14000	14296
1975	15460	15500	15231	15500	15696
1976	15311	16000	15563	16000	15729
1977	15603	16000	15563	16000	15761
1978	15861	16000	15500	16000	15963
1979	16807	16000	15500	16000	16561
1980	16919	16813	16684	16833	16795
1981	16388	16813	16684	16833	16816
1982	15433	16709	15500	16833	16765
1983	15497	16000	15563	16000	15734
1984	15145	16000	15563	16000	15723
1985	15163	16000	15563	16000	15807
1986	15984	16000	15563	16000	15801
1987	16859	16000	15500	16000	16805
1988	18150	16813	16577	16833	16805

Year	Enrollment	Song&Chissom (1993)	Sullivan&Woodall (1994)	Chen (1996)	Proposed Model
1989	18970	19000	19500	19000	19000
1990	19328	19000	19500	19000	19000
1991	19337	19000	19500	19000	19000
1992	18876	19000	19500	19000	19000
MSE		393860.4286	387438.0476	407779.667	258353.4322
PMAD		2.917%	2.646%	2.946%	2.146%

Based on the measurement of MSE and PMAD, we can discover that the forecasting error is dramatically decreasing by implementing the proposed model.

B. The production value of the machinery industry in Taiwan

In order to demonstrate the performance of the proposed method, we use the production value of the machinery industry in Taiwan as the evaluation data. This data contain twelve months ranging from year 2000 to 2001. The following table displays the comparison of various other models which even are one-factor high-order forecasting method.

Table 3 The comparison of various models

Month	Production value	Chen (1996)	Hwang Et al. (atw = 2)	Hwang Et al. (atw = 3)	Hwang Et al. (atw = 4)	Cheng Et al. (2008)	Lui and Wei (2010)	The Proposed method
January 2000	31357	27750	43639	43639	43639	33876	33400	30846
February 2000	24747	30450	31357	31357	31357	31358	25609	28190
March 2000	33509	29100	16347	16347	16347	26530	32179	33065
April 2000	30847	32250	33509	33509	39509	32429	31800	30088
May 2000	35893	30450	30847	26047	26047	31103	32350	32798
June 2000	36340	38550	36493	41893	41893	35672	35612	33431
July 2000	34777	38550	38740	36940	36940	35895	36662	33540
August 2000	34825	38550	33577	33577	31777	35460	34060	33132
September2000	36153	38550	33625	35425	35425	35484	35476	33199
October 2000	35552	38550	36753	36753	36753	35802	36348	32224
November 2000	34718	38550	36152	36152	36152	35848	36396	34070
December 2000	37432	38550	35318	35318	35318	35431	37009	33627
January 2001	26343	27750	39832	39832	39832	32873	29293	28917
February 2001	28280	29100	26343	26343	26343	26817	21514	28773
March 2001	32450	27750	28280	30680	28880	29306	37810	30183
April 2001	29055	32250	34850	34850	36650	31900	31218	28854
May 2001	30195	27750	29655	27855	27855	29694	30908	29721
June 2001	29259	30450	28995	30795	30795	30021	28577	28873
July 2001	27391	30450	29859	29859	29859	29796	29054	29568

Month	Production value	Chen (1996)	Hwang Et al. (atw = 2)	Hwang Et al. (atw = 3)	Hwang Et al. (atw = 4)	Cheng Et al. (2008)	Lui and Wei (2010)	The Proposed method
August 2001	28403	27750	26191	26191	24391	27852	25461	28787
September 2001	25837	27750	27203	29003	29003	29368	28934	28398
October 2001	26665	29100	24637	22837	22837	26564	25647	29212
November 2001	26966	27750	25465	27265	27265	26978	27298	29466
December 2001	28733	2750	27566	27566	27566	27640	30063	
MSE		9313826	33786748	37751698	4276448	8976939	5903856	3300087
PMAD		8.609%	12.517%	13.813%	15.583%	6.958%	5.994%	6.420%

Table 3 indicates that the proposed method has the smallest MSE (3300087) while the PMAD (6.420%) is just bigger than Liu and Wei's method (5.994%). However, Liu and Wei's method is more complicated and considering more effects than the proposed model. Hence, the indices show that the proposed method can efficiently increases the forecasting accuracy compared to other fuzzy time series methods that we displayed.

CONCLUSIONS

In this study, we have developed an improved fuzzy time series forecasting model based on the consideration of rule frequency. This simple and efficient method considers the influence of rule frequency and forecasts more accurately. Moreover, this model resolves the drawback of traditional fuzzy time series forecasting method that ignores the counts of rules but just concerns whether the rule is defined or not.

There may be some suggestions being addressed for future research. First, improving this model to high-factor forecasting method, therefore, the more factors are considered, the more data can be conducted. Second, we just conduct the equal length interval method to partition the universe of discourse; therefore, we may combine other fuzzification methods in the future and desire to get better forecasting results.

ACKNOWLEDGEMENTS

REFERENCE

1. Chen, S.-M., & Hwang, J.-R. (2000). Temperature prediction using fuzzy time series. *Systems, Man, and Cybernetics, Part B: Cybernetics, IEEE Transactions on, 30*(2), 263-275.

2. Chen, S. M. (1996). Forecasting enrollments based on fuzzy time series. *Fuzzy Sets and Systems, 81*(3), 311-319.

3. Chen, S. M. (2002). Forecasting enrollments based on high-order fuzzy time series. *Cybernetics and Systems, 33*(1), 1-16.

4. Chen, S. M., & Chung, N. Y. (2006). Forecasting enrollments using high-order fuzzy time series and genetic algorithms. *International Journal of Intelligent Systems, 21*(5), 485-501. doi: Doi 10.1002/Int.20145

5. Cheng, C.-H., Chen, T.-L., Teoh, H. J., & Chiang, C.-H. (2008). Fuzzy time-series based on adaptive expectation model for TAIEX forecasting. *Expert Systems with Applications, 34*(2), 1126-1132. doi: http://dx.doi.org/10.1016/j.eswa.2006.12.021

6. Huarng, K. (2001). Heuristic models of fuzzy time series for forecasting. *Fuzzy Sets and Systems, 123*(3), 369-386.

7. Hwang, J.-R., Chen, S.-M., & Lee, C.-H. (1998). Handling forecasting problems using fuzzy time series. *Fuzzy Sets and Systems, 100*(1-3), 217-228. doi: 10.1016/s0165-0114(97)00121-8

8. Lee, L.-W., Wang, L.-H., Chen, S.-M., & Leu, Y.-H. (2006). Handling forecasting problems based on two-factors high-order fuzzy time series. *Fuzzy Systems, IEEE Transactions on, 14*(3), 468-477. doi: 10.1109/TFUZZ.2006.876367

9. Li, S.-T., & Cheng, Y.-C. (2007). Deterministic fuzzy time series model for forecasting enrollments. *Computers & Mathematics with Applications, 53*(12), 1904-1920. doi: 10.1016/j.camwa.2006.03.036

10. Li, S.-T., & Cheng, Y.-C. (2010). A Stochastic HMM-Based Forecasting Model for Fuzzy Time Series. *Systems, Man, and Cybernetics, Part B: Cybernetics, IEEE Transactions on, 40*(5), 1255-1266. doi: 10.1109/TSMCB.2009.2036860

11. Liu, H.-T., & Wei, M.-L. (2010). An improved fuzzy forecasting method for seasonal time series. *Expert Systems with Applications, 37*(9), 6310-6318.

12. Own, C.-M., & Yu, P.-T. (2005). Forecasting Fuzzy Time Series on a Heuristic High-Order Model. *Cybernetics and Systems, 36*(7), 705-717. doi: 10.1080/01969720591008922

13. Song, Q., & Chissom, B. S. (1993). Fuzzy Time-Series and Its Models. *Fuzzy Sets and Systems, 54*(3), 269-277. doi: Doi 10.1016/0165-0114(93)90372-O

14. Sullivan, J., & Woodall, W. H. (1994). A comparison of fuzzy forecasting and Markov modeling. *Fuzzy Sets and Systems, 64*(3), 279-293. doi: http://dx.doi.org/10.1016/0165-0114(94)90152-X

15. Yu, H.-K. (2005). Weighted fuzzy time series models for TAIEX forecasting. *PhysicaA: Statistical Mechanics and its Applications, 349*(3), 609-624.

FORECASTING HIGH ORDER FUZZY TIME SERIES
WITH MINIMUM RECENT ORDERS

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ABSTRACT

Time series usually oscillate between likely trends in nature. Although high order fuzzy logical relationship may capture trends in time series, it still cannot precisely predict the situation which cannot find the same FLR in training data. Even if we can find the same FLR, it doesn't mean that the linguistic class will be the same. Therefore, in the steps of fuzzification and rule establishment we not only use the larger membership degree be a linguistic class, but also take the smaller one into consideration and separate it into major and minor linguistic class. Finally we use KNN method to search the similar FLR. However, in time series, sometimes the best order which is quite large will lead to inconvenience in practice. In order to use the shortened order but also keep the high accuracy, we proposed the concept of minimum recent orders (MRO) using the uniqueness of LHS and consistency of RHS to find the MRO in each record in the training data to early predict the result.

Keyword: fuzzy time series, fuzzy logical relationship, predict, KNN

INTRODUCTION

In the information explosion era, enterprises usually use data mining or variety of techniques to analyze the likely next step of customer's behavior or trend in order to get the higher satisfaction and also increase self-profits. However, along with information technology in

progress, the storage methods of the information are getting more complexity. The information presentations not only use traditional data, but also include some vague data type which cannot express in preciseness. Thanks to Zadeh (1965) who proposed fuzzy theory, the vague but useful data begin to be handled to make appropriate decisions. According to fuzzy theory, Song & Chissom (1993) first proposed fuzzy time series to deal with the case of vague data in time series. Later, Sullivan &Woodall (1994) improved the results by using Markov matrix based on probability statistics to establish one-factor one-order time invariant fuzzy time series forecast model. Because of complexity of matrix computing, Chen (1996) proposed fuzzy logical relationship group (FLRG) and combine with simple arithmatic operators to reduce the complexity. Hwang, Chen & Lee (1998) were further extended the time-variant method which proposed by Song & Chissom (1994) into criterion matrix and operation matrix to highlight the importance of the last timestamp. Huarng (2001) first had the different thinking about interval partition and thought that the length of interval or data distribution will influence the forecasting accuracy. Therefore, he proposed distribution-based and average-based methods to partitioning the intervals. Chen (2002) extended his previous work, Chen (1996), into high order fuzzy logical relationship group. However, the repeated rules were viewed as useless and deleted until Yu (2005) proposed weighted fuzzy time series. Yu (2005) thought that the repeated rules should have some important values, thus, gave the different weight according to chronological order to forecast TAIEX.

The above methods we introduced were all used one factor to forecast, but in realistic circumstances, there are more than one factor affect the main factor, such as well-known data set Taipei temperature and cloud density. If we can analyze more factors, we can get the higher accuracy rate. Li & Cheng (2007) proposed an innovative idea to deal with high-order problem. For some vague rules, Li & Cheng (2007) used the concept of state transition diagram to backtrack to the stable state. The deterministic fuzzy time series not only solved the order determination but also the situation of ambiguous rules. Cheng, Chen & Wu (2009) first used weighted fuzzy time series to compare with technical innovation theory and got the better accuracy rate when predicted ICT products. Wang & Chen (2009) proposed two-factor fuzzy time series model and used automatic clustering techniques to partition intervals. Chen & Chen (2011) renovated the method of building up fuzzy logical relationship to a way of using variation and tried to find possible trends to predict. Joshi & Kumar (2012) first extended fuzzy sets into intuitionistic fuzzy sets and used IFS construction method to determine membership degree. Shah (2012) proposed an unequal length interval method and based on rule database to capture likely prevailing trends.

Although fuzzy time series has been developed for a decades, there are still some problems. For the method of high order fuzzy time series many scholars place restrictions of defuzzification on matching identical rules. This approach can obtain higher accuracy in an in-sample way, but not fit in with real situation. However, if we adopt out-sample method, the lower successful matching proportion will be get. Therefore, in high-order fuzzy time series fuzzification and rules establishment this study not only uses the biggest membership value as its main linguistic class but also take the second one into consideration which can be divided into major and minor

linguistic class, and in the forecasting step, we combine with KNN method to find some similar fuzzy logical relationships. The order of high-order fuzzy time series is also a problem. Sometimes it will be inconvenient to get the information in practical when the best prediction order of the data set is quite large. To overcome these problems, we proposed the concept of minimum recent orders which is conducted by the LHS uniqueness and RHS consistency to find the minimum orders in each training data in the second stage.

UNDERLYING THEORIES AND TECHNIQUES

In this section, we briefly review the theories and techniques that are related to this research, which include fuzzy time series (FTS) and KNN method.

2.1 Fuzzy Time Series

Definition 1: Let $1\ Y(t) \in R\ (t = 0,1,2,\dots)$ be the universe of discourse in which fuzzy sets $f_i(t)$ ($i = 1,2,\dots$) are defined, and let $F(t)$ be a collection of $f_i(t)$. Then, $F(t)$ is called a fuzzy time series on $Y(t)$ ($t = 0,1,2,\dots$).

Definition 2: If $F(t-1)$ is transformed into linguistic variable A_i, $F(t)$ is A_j, then the relationship between A_i and A_j can be expressed as or $F(t-1) \to F(t)$ or $A_i \to A_j$ The left of arrow is called left hand side (LHS); right of it is called right hand side (RHS). If there are many RHS map to the same LHS, we can group the rules as $A_{i1} \to A_{j1}, A_{j2}, \dots, A_{jn}\ A_{i2} \to A_{j1}, A_{j2}, \dots, A_{jn}\ A_{ik} \to A_{j1}, A_{j2}, \dots, A_{jn}$.

Definition 3: Let $1\ F(t-n) = A_{i1}, F(t-n+1) = A_{i2}, \dots, F(t-1) = A_{in}$ then the fuzzy logical relationship of nth-order is as $F(t-n), F(t-n+1), \dots, F(t-1) \to F(t)$ or $A_{1i}, A_{2i}, \dots, A_{1n} \to A_j$

Definition 4: Let $F(t)$ be a fuzzy time series which jointly decided by $(F_1(t-1), F_2(t-1), F_1(t-2), F_2(t-2), \dots, F_1(t-n), F_2(t-n))$, the fuzzy logical relationship of two factors then can be shown as $(F_1(t-1), F_2(t-1), F_1(t-2), F_2(t-2), \dots, F_1(t-n), F_2(t-n)) \to F(t)$, where $F_1(t)$ is main factor, $F_2(t)$ is secondary factor.

2.2 K-Nearest Neighbors (KNN)

The following will briefly introduce the process of KNN method.

Step1: Compute the distance or similarity for each testing data $z = (\acute{x}, \acute{y})$ and training data $(x, y \in D$ to decide k nearest data points D_z.

Step2: Testing data will base on the majority of classes(Eq1.) in the k nearest neighbors to decide the classifiedresult.Where v is a class tag, y_i is one of the class of k nearest neighbors, $I(.)$ is an indication function. If the argument is true returns 1, otherwise returns 0.

Majorit Voting Method：$\acute{y} = arg_v max \sum_{(x_i,y_i) \in D_2} I(v = y_i)$ (Eq1.)

FORECASTING HIGH ORDER FUZZY TIME SERIES WITH MINIMUM RECENT ORDERS

3.1 High-order Fuzzy Time Series Forecasting Model

Step1: Data set partitioning and order setting

This study use two thirds of the historical data to be training data and the others are testing data. Due to the size of the order will affect the amount of the testing data and it is meaningless to have large order in time series. Therefore, in order to keep the validity of the result, the maximum order is set to the half of the testing data and should not be more than 30. The process of this section will increase the order sequentially trying to find the best result.

Step2: Define universe of discourse (U)

First, subtract two consecutive training data to compute the differences and then to find the minimum difference D_{min} and maximum D_{max}. Therefore, the universe of discourse can be $U = [D_{min} - D_1, D_{max} + D_2]$. D_1 and D_2 are decided by the analyst.

Step3: Define fuzzy set and fuzzify historical data

In this study we conduct equal length interval method to partition universe of discourse into n intervals $u_1, u_2, \ldots, u_n$; therefore, we have fuzzy set $A_1, A_2, \ldots, A_n$. Let $u_i = [u_{i1}, u_{i2}]$ and $A_i = [A_{i1}, A_{i2}, A_{i3}]$, where A_{i2} is the midpoint of the intervals. The corresponding relationship between u_i and A_i are as below.

$$
\begin{cases}
A_i = \left[u_{i1}, \dfrac{u_{i1} + u_{i2}}{2}, \dfrac{u_{(i+1)1} + u_{(i+1)2}}{2}\right] & , i = 1 \\[3mm]
A_i = \left[\dfrac{u_{(i-1)1} + u_{(i-1)2}}{2}, \dfrac{u_{i1} + u_{i2}}{2}, \dfrac{u_{(i+1)1} + u_{(i+1)2}}{2}\right] & , 1 < i < n \\[3mm]
A_i = \left[\dfrac{u_{(i-1)1} + u_{(i-1)2}}{2}, \dfrac{u_{i1} + u_{i2}}{2}, u_{i2}\right] & , i = n
\end{cases}
$$

When a value approaches to the center of linguistic value A_i, it means the greater degree belongs to the linguistic class A_i, thus, the membership degree is closer to 1. Each value has two linguistic classes and corresponding membership degrees in most case, but the past literatures ignored the smaller one. However, in our study, we think that although smaller it is, it still has some valuable information can take. Therefore, we define the larger one to be major linguistic class and the smaller one to be minor linguistic class.

Step4: Build up fuzzy logical relationship

In this step we conduct the concept of sliding windows to build up high-order fuzzy logical relationships. The left hand side (LHS) only considers the major linguistic values to establish rules, and the right hand side (RHS) is the corresponding major and minor class. If the rules appear more than once, then we merge the rules as the following equation $A_{i(t-0)}, A_{i(t-0+1)}, \ldots\ldots, A_{i(t-1)} \rightarrow [A_{ij1}, A_{ij2}]$, where i is the number of not repeated rules, t

is the forecasting time period which means the part of RHS, o is the order we used, A_{ij1} and A_{ij2} is the major class and minor class of the ith rule respectively. if the membership degree are different in the merge process, then average it to get a new one.

Step5: Forecast and defuzzification

Step5.1: Find K similar rules

Use Eq.(2) to calculatesimilar degree between forecasting rules and training data.where represent the training rule, $ś$ denote as forecasting rule which we want to predict, L is the order we used and K is the initial parameter decided by the analyzer. Let the value of $k - th$ smallest distance between forecasting rule and training rules be n, if the number of all distance $\leq n$ is larger than K, then we change K to be the number.

$$dist(s, ś) = \sqrt{\sum_{i=1}^{L}(s[i] - ś[i]^2)}$$

(Eq2.)

Step5.2: Defuzzification

In this defuzzification step, we also take the minor linguistic class to defuzzify. The defuzzification method is defined in the Eq3. Where C_{ijl} is the midpoint of major and minor linguistic class; μ_{ijl} is the corresponding membership degree; K is the parameter which means the number of selected rules; x_{t-1} is the real value of last time period for the time t. Note that the value of i will be changed by the different value of K.

$$forecast = (\sum_{l=1}^{K}\left(\frac{\sum_{i=1}^{m}\sum_{i=1}^{2}c_{ijl}\times\mu_{ijl}}{\sum_{i=1}^{m}\sum_{i=1}^{2}\mu_{ijl}}\right)/K) + x_{t-1} \qquad \text{(Eq3.)}$$

Minimum Recent Orders (MRO) Establishment

This section has two parts, one is to introduce the method of MRO, and another is the new defuzzification method.

Establish the method of LHS uniqueness

Execute the training rules from first down to the end sequentially. Each rule start on the timestamp = t -1 and compare linguistic value with the rest of the training rules at the same time period, if the rules are found the same, then record it for the next timestamp. Repeat the above step until no rules are the same in the one of timestamps, and then record the MRO of the training rule to be the number of rounds. If the training rule is run to the timestamp = t – o and still have the same rules, then record the MRO of the training rule to be .

LHS uniqueness and RHS consistency

The following is the process of this method.

1. Average all the main class in each training rule, the formula is shown in Eq4. Whereis the number of all main class in the i training rules.

$$\sum_{j=1}^{n} A_{ij1}/n \qquad\qquad \text{(Eq4.)}$$

2. Based on the fuzzy set which is defined in the first stage we can know how many linguistic values A_i in it. Where $i = 1 \sim m$.

Begin with A_1 to perform following steps sequentially, and repeat it until A_m

3. Find all the training rules which linguistic value is A_i in timestamp = t -1. Let the amount of rules is , therefore, we have $rule_1$ to $rule_{pn}$.

Sequentially perform the following steps from $rule_1$ to $rule_{pn}$.

Sequentially perform timestamp = (t – n),where $n = 1 \sim o$.

4. Compare $rule_j$ and the rest of $pn - 1$ training rules, find whether the linguistic value is the same at the timestamp = (t – n). If no one matches, it represents the $rule_j$ have the property of LHS uniqueness. Therefore, record the MRO to be n and j+1 back to the step 4, otherwise, perform next step.

5. Compare the averaged main class of $rule_j$ with the other rules in timestamp = (t – n). If the absolute value after subtract from each other ≤ 0.5 , it represent that the two training rules are have the property of RHS consistency, therefore, record the MRO and $j+$ 1 back to the step 4. If the absolute value is larger than 0.5, then $n + 1$ back to the step 4; If $n = o$, record the MRO to o be , and back to the last step.

Defuzzification Method for Minimum Recent Orders
The following steps are the defuzzification method for the MRO.

1. Sequentially get the linguistic value at timestamp = (t – n) for the forecasting time period t until the MRO of at least one of the K nearest neighbors are smaller or equal to n, where $n =$ $1 \sim o$, then take these rules to defuzzify. K is the parameter which is decided by the analyst. Let the value of k-th smallest distance between forecasting rules and training rules be n, if the number of all distance $\leq n$ is larger than K, then we change K to be the number.

2. The defuzzification method is equal to the Eq3.

EXPERIMENTS AND ANALYSIS

In this chapter, we compare our proposed method with other fuzzy time series forecasting models. In order to verify the accuracy and validity, we conduct experiments with Taipei power usage from the year 2007 to April 2013. We uses two
third of the data to be training data, the others is testing data and take four measurement to verify the results.

1. RMSE (Root Mean squared error)

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(Forecasting_{Value_i} - Actual_{Value_i})^2}{n}}$$

2. MAE (Mean Absolute Error)

$$MEA = \frac{\sum_{i=1}^{n}\left|Forecasting_{Value_i} - Actual_{Value_i}\right|}{n}$$

3. PMAD (Percent Mean Absolute Deviation)

$$PMAD = \frac{\sum_{i=1}^{n}\left|Forecasting_{Value_i} - Actual_{Value_i}\right|}{\sum_{i=1}^{n}|Actual\_Value_i|}$$

4. MAPE (Mean Absolute Percentage Error)

$$MAPE = \frac{\sum_{i=1}^{n}\left|\frac{Forecasting_{Value_i} - Actual_{Value_i}}{Actual\_Value_i}\right|}{n}$$

We set K=3 and divide the universe of discourse into seven intervals. The result will be compared with the forecasting model of Song & Chissom (1994), Chen (1996), Wu (2003), Yu(2005), Li & Cheng (2007) and Chen (2011). The value which marks '*' is the best result compared with other models.
result compared with other models.

Table 1. Forecasting accuracy of Taipei power usage

	MAE	MAPE	RMSE	PMAD
S&C(1994)	56885270	0.145956	66327059	0.145204
Chen(1996)	51337517	0.131119	59036563	0.131043
Wu (2003)	48697280	0.126104	59095370	0.124304
Yu (2005)	44043944	0.114317	48255341	0.112426
Li & Cheng (2007)	52978752	0.144038	73784974	0.135233
Chen (2011)	58522708	0.148901	95844634	0.148276
Proposed model	12329620*	0.034273*	15332567*	0.03264*

Table 2. The KNN result from 1 to 4 of Taipei power usage

| | MAE | | RMSE | PMAD |
	MAPE			
K=1	13458571	0.035926	17144930	0.036305
K=2	12001953*	0.0324*	15828235*	0.031772*
K=3	12329620	0.034273	15332567	0.03264
K=4	14912359	0.040444	19921746	0.039477

The following table3 compares the MRO method. The method list in the first row is the best order in high-order fuzzy time series forecasting model, we denote as full KNN. The second row is the method of LHS uniqueness, denote as MRO-1 and the last row is LHS uniqueness and RHS consistency method, denote as MRO-2.

Table 3.MRO method evaluation of Taipei power usage

	AveragedOrder	MAE	MAPE	RMSE	PMAD
Full KNN	6	12329620	0.034273	15332567	0.03264
MRO-1	3.1	38782000	0.102019	49961383	0.102666
MRO-2	2.9	38402916	0.100511	50000681	0.101662

CONCLUSIONS

From table 2, we can learn that the best results are got when the value of K is larger than one. It directly prove that the traditional method of using only one completely matching rule may lose some valuable information and cause lower accuracy. The second stage in this research proposed two algorithms to shorten the best high orders and denote as MRO-1 and MRO-2. The different between two methods is that MRO-1 only consider the uniqueness of LHS, however, MRO-2 also take the consistency of class into consideration. The results can be seen from table 3 and we can know that no matter in forecasting orders or accuracy, MRO-2 is better than MRO-1. However, the accuracy of MRO method still has some gap compare to the original. Therefore, we expected the MRO method can be improved to make the accuracy the same or better than the original in the future.

REFERENCE

1. Chen, S-M. (1996). Forecasting enrollments based on fuzzy time series. *Fuzzy Sets and Systems, 81*(3), 311-319. doi: 10.1016/0165-0114(95)00220-0
2. Chen, S-M. (2002). Forecasting enrollments based on high-order fuzzy time series. *Cybernetics and Systems, 33*(1), 1-16. doi: 10.1080/019697202753306479
3. Chen, S-M, & Chen, C-D. (2011). Handling forecasting problems based on high-order fuzzy logical relationships. *Expert Systems with Applications, 38*(4), 3857-3864. doi: 10.1016/j.eswa.2010.09.046

4. Cheng, C-H, Chen, Y-S, & Wu, Y-L. (2009). Forecasting innovation diffusion of products using trend-weighted fuzzy time-series model. *Expert Systems with Applications, 36*(2, Part 1), 1826-1832. doi: 10.1016/j.eswa.2007.12.041

5. Huarng, K. (2001). Effective lengths of intervals to improve forecasting in fuzzy time series. *Fuzzy Sets and Systems, 123*(3), 387-394.

6. Huarng, K, &Yu, T. H-K. (2006). The application of neural networks to forecast fuzzy time series. *Physica A: Statistical Mechanics and its Applications, 363*(2), 481-491. doi: 10.1016/S0165-0114(00)00057-9

7. Huang, K., & Yu, T. H-K. (2006). Ratio-based lengths of intervals to improve fuzzy time series forecasting. *Systems, Man, and Cybernetics, Part B: Cybernetics, IEEE Transactions on, 36*(2), 328-340. doi: 10.1109/TSMCB.2005.857093

8. Hwang, J-R, Chen S-M, & Lee, C-H. (1998). Handling forecasting problems using fuzzy timeseries. *Fuzzy Sets and Systems, 100*(1–3), 217-228. doi: 10.1016/S0165-0114(97)00121-8

9. Joshi, B-P, & Kumar, S. (2012). Intuitionistic fuzzy sets based method for fuzzy time series forecasting. *Cybernetics and Systems, 43*(1), 34-47. doi: 10.1080/01969722.2012.637014

10. Li, S-T, & Cheng, Y-C. (2007). Deterministic fuzzy time series model for forecasting enrollments. *Computers & Mathematics with Applications, 53*(12), 1904-1920. doi: 10.1016/j.camwa.2006.03.036

11. Shah, M. (2012). Fuzzy based trend mapping and forecasting for time series data. *Expert Systems with Applications, 39*(7), 6351-6358. doi: 10.1016/j.eswa.2011.12.036

12. Song, Q., & Chissom, B.S. (1993). Forecasting enrollments with fuzzy time series —Part I. *Fuzzy Sets and Systems, 54*(1),1-9. doi: 10.1016/0165-0114(93)90355-L

13. Song, Q., & Chissom, B.S. (1994). Forecasting enrollments with fuzzy time series —part II. *Fuzzy Sets and Systems, 62*(1), 1-8. doi: 10.1016/0165-0114(94)90067-1

14. Sullivan, J., & Woodall, W.H. (1994). A comparison of fuzzy forecasting and Markov modeling. *Fuzzy Sets and Systems, 64*(3), 279-293. doi: 10.1016/0165-0114(94)90152-X

15. Yu, H-K. (2005). Weighted fuzzy time series models for TAIEX forecasting. *Physica A: Statistical Mechanics and its Applications, 349*(3–4), 609-624. doi: 10.1016/j.physa.2004.11.006

16. Wang, N-Y, & Chen, S-M. (2009). Temperature prediction and TAIFEX forecasting based on automatic clustering techniques and two-factors high-order fuzzy time series. *Expert Systems with Applications, 36*(2, Part 1), 2143-2154.

DECISION OF PROPER ECONOMIC ANALYSIS METHODS FOR THE INNOVATION INVESTMENT

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ABSTRACT

Economic analysis is one of the necessary steps for the successful commitment of the innovation investment. However, there are so many different economic analysis methods that engineers are very confused which to choose and apply for their own projects. For this problem, this paper will present all the present economic evaluation methods in practice with their meanings and characteristics, and will find out valuable methods by use of classification and analysis. So that this will lead decision makers feel easy when they choose the proper analysis method and help to the right economic decision for their innovation investment.

Keywords: Economic analysis, Innovation investment, Classification and analysis, Proper analysis method, Right economic decision,

INTRODUCTION

Technology innovations are usually performed by the engineers and those want some investment for enterprise to make valuable products with them. In other words, one of the important purposes of technology innovation is the profit. That's why technology should be judged not only by the physical efficiency but also economic efficiency. Therefore, decision makers, especially engineers should understand the value of the technology which they try to develop. The value can be counted by the comparison between the input and the output in the economic view. The main interest of investors is the profit from the technologies that engineers are developed and created. That's why engineers have to know how the economic analysis is performed before they start the innovation projects.

But the problems of the economic analysis for engineers are in the abundance and variety of analysis methods which are hard to understand and apply. That is, there are so many different types of economic analysis methods which sometimes make different conclusions that engineers feel so confused. But, actually engineers do not need to understand all of the economic methods because it is not necessary to apply all the methods for right decision. Then, the problem is how to distinguish the essential methods from the pool of various analysis methods. For this problem, this paper collects all the possible economic analysis methods around us and presents the meanings and characteristics of the each method. And then the methods are classified and analyzed by use of various criteria to choose suitable one for the innovation investment. The results

will make engineers feel comfortable in the choosing and studying the economic analysis methods to decide whether their engineering projects are valuable.

INVESTIGATION OF ECONOMIC ANALYSIS METHODS

Economic analysis method can be defined as a technique which helps investors to decide the best economic alternative. Economic alternative means the alternative that makes bigger profits or advantages than the others. But the best economic alternative can be different depending on the economic circumstance of projects. That's the one of the reason why so many economic analysis methods are present. Thus engineers have to know the reasons of existence of each method and should be able to apply the actual meanings of each analysis method. To solve these problems, the definitions and characteristics of each economic analysis method are represented as follows.

(1) Net present value method (NPV)
Present value means the result of transforming the future value into present value by use of given discount rate. Therefore net present value means the monetary gap between the present value of life cycle revenues of a project and that of costs. The method judges as economic when net present value is bigger than 0.

(2) Net annual value method (NPA)
It is the same method as the net present value method except the annual value in substitution of present value. It is useful when annual values are compared.

(3) Internal rate of return method (IRR)
Rate of return means the rate of interest that makes the present value of life cycle revenues equals that of costs. So, internal rate of return represents the rate of interest that makes net present value of a project 0. Therefore when the rate of return of a project is bigger than the required marginal attractive rate return, the project is judged as being economic.

(4) Payback period method (PB)
Payback period means the time period when sum of the annual revenues gets over the amount of the initial investment. Thus when the payback period is shorter than the required time span, the project is judged as being economic. PB is a good indicator of fast capital recovery.

(5) Profitability index method (PI)
Profitability index means the ratio of sum of the present value of life cycle revenues divided by the sum of the present value of life cycle costs of a project. Thus, it is considered as economic when the profitability index is bigger than 1.

(6) Benefit Cost analysis method (BC)

It is same as profitability index method. But here, present value of the revenues includes wide range of the benefits that occurred by the project such as publicconstruction.

(7) Accounting rate of return method (ARR)

Accounting rate of return means the ratio of net annual average revenues after tax and depreciation divided by annual average value of properties invested for a project. The data of net revenues comes from the accounting P/L statement. It is considered as economic when the accounting rate of return is bigger than the required rate of return.

(8) Return on investment method (ROI)

Return on investment means the ratio of accounting net profit of that year divided by the total investment of the company. Therefore, it represents the production or financial performance of that year of a company, and it is considered as successful when the ROI index is bigger than the required rate of return.

(9) Economic value added method (EVA)

Economic value added means the amount of money made by a company of a year over the costs including tax and cost of capital. It is used as a management index that shows how much a company made profit over the invested capital.

(10) Break-even point method (BEP)

Break-even point means the amount of production of a year that make the revenue and the cost of a company same. Thus break-even point method can indicate how much production a company needs to make earnings and expenses even. So, the size of demand or order per year of that product can be a criterion of investment.

(11) Real options method (RO)

Real options method includes the concepts of future fluctuation of decision corresponding to the change of managerial circumstances of a company. It is usually applied in addition to the traditional decision analysis such as NPV. But it is hard to understand and sometimes subjective.

CLASSIFICATION OF ECONOMIC ANALYSIS METHODS

Now we can find that there are too many analysis methods to apply. Thus, it is necessary to reduce the number of the methods as well as to choose the essential and convenient methods to use. The results are derived by use of following classification schemes as follows.

<Table 1> Classification by evaluation measure

Evaluation measure	Analysis method
Amount of money	NPV, NPA, EVA, RO
Ratio of output/input	IRR, PI, BC, ARR, ROI
Time of capital recovery	PB
Amount of production	BEP

<Table 2> Classification by decision basis

Decision basis	Analysis method
0	NPV, NPA, EVA, RO
1	PI, BC
Required ratio	IRR, ARR, ROI
Required time	PB
Break even amount	BEP

<Table 3> Classification by frequency used in Forbes 500 Co.

Use frequency	Analysis method
Above 50%	NPV, IRR, PB
Below 50%	ARR, PI, RO
Record not available	NPA, BC, ROI, EVA, BEP

<Table 4> Classification by the time value of money

Time value of money	Analysis method
Adapted	NPV, NPA, IRR, PI, BC, BEP, RO
Not adapted	PB, ARR, ROI, EVA

<Table 5> Classification by the life cycle

Life cycle time	Analysis method
Included	NPV, NPA, IRR, PI, BC, RO, BEP, PB, ARR
Not included	ROI, EVA

<Table 6> Classification by target of evaluation

Target of evaluation	Analysis method
Project	NPV, NPA, IRR, PI, BC, RO, BEP, PB, ARR
Company	ROI, EVA

<Table 7> Classification by data used

Data used	Analysis method
Cash flows of project	NPV, NPA, PB, IRR, PI, BC, RO
Accounting data in company	ARR, ROI, EVA

<Table 8> Classification by ease of use

Level of simplicity	Analysis method
Easy without interest	PB, ARR
Fair with interest	NPV, NPA, IRR, PI, BC, ROI, EVA, BEP
Complicated	RO

DISCUSSION AND CONCLUSION

Innovations are not always useful or successful in the real world. That's not because of its poor idea but because of its lack of economic efficiency. However, innovators sometimes forget the importance of economic aspects in their projects. But when you try to apply the economic evaluation method, you will realize that there are quite many methods that you will be confused what to choose. To solve that problem, this paper collected most of all the possible economic analysis methods that are used in field. And the methods are classified and analyzed for the selection of simple and useful methods. According to the classifications in chapter 3 the following analyses could be derived.

1. Since ROI and EVA are made for the evaluation of a company's accomplishment (Table 6) and also they neglect time value of money (Table 4), they are not recommended for the economic evaluation of a project.
2. RO is too complicated to use (Table 8).
3. NPA, BC and BEP are sometimes useful, but PIC, ARR, PI are not considered useful so much (Table 4, 5, 6, 8).
4. NPV, IRR, PB are popular in real world (Table 3)
5. ARR, ROI, EVA are not appropriate for project evaluation due to the lack of cash flows data (Table 7)

Therefore, as a result of the analyses, the following table 9 is derived.

<Table 9> Useful & simple analysis methods in grade

Grade	Analysis method
Excellent	NPV, IRR, PB
Good	NPA, BC, BEP
Fair	PIC, ARR, PI, RO
Poor	ROI, EVA

As a conclusion, the methods of NPV, IRR, PB are necessary and probably enough for normal economic analysis. Thus, the innovators are required to understand those 3 methods for self economic evaluation of their planning projects, and the others are optional. Especially, ROI and EVA are designed for the annual accomplishment of a company that they are not suitable for project evaluation.

REFERENCES

1. Park, CS, 2002, Contemporary engineering economics, Third edition, Prentice Hall
2. Park, YT, 2005, Technology Management, Life & Power Press
3. Kim, MS, Valuation of stocked enterprises by use of traditional WACC, Miles-Ezzel model and APV, Doctorial dissertation in Dept. of Management of Kyunghee Univ. 2003
4. KISTEP, 2011, Standard index for preliminary evaluation study on R&D projects
5. SBC, 2002, Economic evaluation guide for investment in small & medium business
6. Shim, KS, The study on the economic analysis of international passenger terminal and marina facilities, KMI, 2007
7. Yoo, IG, 2003, Business evaluation analysis and management strategy, Hyungseol press
8. Yoo, IG, 2009, New engineering economy, Second edition, Hyungseol press

DETERMINATION OF SOFTWARE RELEASE TIME WITH ERROR COUNT AND TESTING TIME

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ABSTRACT

Purpose: *This paper presents a method to determine the software release time with two decision criteria, the major errors corrected and the testing time elapsed. Under the policy, the software is tested until a predetermined number of major errors are corrected or some length of testing time elapsed, whichever comes first. Then the software is released.*

Design/methodology/approach: *The errors in software are classified into two types, major or minor errors. The expected total lifecycle cost of correcting major and minor errors during test and after release is derived based on a software reliability growth model. The optimum values of policy variables that minimize the total cost are explored.*

Findings: *A stochastic cost model is obtained to find the optimum software release time. The proposed policy has some relative advantages than other policies that use only one decision variable. The optimal values of policy variables can be obtained by solving equations.*

Research limitations/implications: *The presented model is a conceptual approach for deciding the software release time. The software lifecycle is assumed infinite.*

Practical implications: *The software developer can use the presented model to determine the cost optimal software release time.*

Originality/value: *This paper presents a new approach to the area of the optimum software release model.*

Keywords: software test, software release, lifecycle cost, software reliability growth

Paper type: Research paper

INTRODUCTION

As the size of computer software becomes large and complex, the cost of developing a software system goes higher. It is thus an important issue to determine when we stop the test and release the software to satisfy the software reliability requirement and to minimize the cost involved.
The reliability of software in general depends on the time spent in testing the software. A longer testing time means an increased reliability, but it incurs also an increased cost in testing. On the other hand, an insufficient testing might cause failures after release which cost more than in the testing phase.

The determination of software testing time which minimizes the total software lifecycle cost is a trade-off between some conflicting cost components. The software lifecycle cost is mainly divided into two parts, the cost before release and after release. As we increase the testing time, the cost before release increases and the cost after release decreases, and vice versa. The optimal software release time is the time that minimizes the expected total lifecycle cost.

The problem of determining the software testing time which guarantees a reliability requirement or minimizes the total cost involved is called the optimal software release problem. A pioneering research on this topic is attributed to Okumoto and Goel (1980). Based on their non-homogeneous Poisson process (NHPP) software reliability growth model (SRGM) (Goel and Okumoto, 1979), they presented two criteria, software reliability and total lifecycle cost, to find the optimum release time. Yamada and Osaki (1985) developed a method which satisfies these two criteria simultaneously. Other numerous researches on this topic can be found in literatures (e.g., Boland and Chuiv 2007, Chatterjee et al. 1997, Hou et al. 1997, Huang 2005, Koch and Kubat 1983, Pham and Zhang 2003, Xie and Hong 1999).

The previous researches have dealt with the problem without any distinction between the seriousness of errors. The software errors during operation can cause different types of failures as a result. Pham (2000) identifies four types of software failures: catastrophic, critical, major, and minor.

In this study, the software errors are simply divided into two types, major and minor errors. Using the NHPP SRGM of Goel and Okumoto (1979), we present a method to determine the optimal software release time which minimizes the total lifecycle cost. The software errors are composed of some proportion of major and minor errors. We assume that the errors detected during test can be classified as major or minor, and can be corrected immediately. The software test continues until the Nth major errors are corrected or the testing time T elapses, whichever comes first. Then the software is released.

Most previous researches have used the testing time T as a decision variable for determining the optimum release time. The number of errors corrected is used as a decision variable in Bai and Yun (1988) for Jelinski-Moranda SRGM and decreasing failure rate SRGM, and Shinohara et al. (1997) for Jelinski-Moranda SRGM and logarithmic Poisson execution time SRGM. In this paper, the software errors are classified into two categories and the NHPP SRGM is used to derive the total lifecycle cost which will be minimized with two decision variables, the testing time T and the number of major errors corrected N.

GOEL-OKUMOTO NHPP SRGM

The NHPP SRGM which will be used in this paper was proposed by Goel and Okumoto (1979) and is summarized as follows. As the software test proceeds, errors are detected and corrected immediately. The occurrence or arrival of errors is assumed to follow an NHPP. Let

$$N(t) = number\ of\ errors\ detected\ during\ (0, t].$$

Since $\{N(t), t \geq 0\}$ is an NHPP,

$$P\{N(t) = k\} = \frac{[m(t)]^k e^{-m(t)}}{k!}, k = 0, 1, 2, ..., \tag{1}$$

and the mean value function $m(t)$ and the intensity function $\lambda(t)$ are given by

$$m(t) = E[N(t)] = a(1 - e^{-bt}) \tag{2}$$

$$\lambda(t) \equiv m'(t) = abe^{-bt} \tag{3}$$

where, $a = m(\infty)$ implies the expected number of errors in the software, and b is the hazard rate of an error.

(N,T) SOFTWARE RELEASE POLICY

The (N,T) policy proposed in this paper uses two decision variables. We stop the software test and release when the Nth major errors are corrected or the testing time T elapses, whichever arrives first. The errors in the software are classified into two types, major or minor. Let p be the proportion of major errors and $q = 1 - p$ be the proportion of minor errors. Also let

$$N_1(t) = number\ of\ major\ errors\ detected\ during\ (0, t]$$

$$N_2(t) = number\ of\ minor\ errors\ detected\ during\ (0,t].$$

Then by the decomposition property of Poisson process (Ross, 1983), $\{N_1(t), t \geq 0\}$ and $\{N_2(t), t \geq 0\}$ are independent NHPP with respective mean value function

$$E[N_1(t)] = pm(t) = pa(1 - e^{-bt}) \tag{4a}$$

$$E[N_2(t)] = qm(t) = qa(1 - e^{-bt}). \tag{4b}$$

Let T_N be the time to the Nth major error detection under the proposed policy. Then from the relation

$$\{T_N > t\}\ if\ and\ only\ if\ \{N_1(t) < N\},$$

the survival function of T_N is given by

$$\begin{aligned}
P\{T_N > t\} &= P\{N_1(t) < N\} \\
&= \sum_{k=0}^{N-1} P\{N_1(t) = k\} \\
&= \sum_{k=0}^{N-1} \frac{[pm(t)]^k e^{-pm(t)}}{k!}.
\end{aligned} \tag{5}$$

To obtain the expected duration of software testing time, let $T_M = min\{T, T_N\}$. Then by conditioning on the arrival of Nth major error detection,

$$\begin{aligned}
E[T_M] &= E[min\{T, T_N\}] \\
&= TP\{T_N > T\} + \int_0^T t\,dF(t) \\
&= \int_0^T P\{T_N > t\}dt \\
&= \sum_{k=o}^{N-1} \int_0^T \frac{[pm(t)]^k e^{-pm(t)}}{k!}\,dt,
\end{aligned} \tag{6}$$

where $F(t)$ denotes the distribution function of T_N.

To obtain the total cost incurred before and after release, define the following cost parameters.

$$c_{m1} = cost\ of\ correcting\ a\ major\ error\ during\ test$$
$$c_{m2} = cost\ of\ correcting\ a\ major\ error\ after\ release, c_{m2} > c_{m1}$$
$$c_{n1} = cost\ of\ correcting\ a\ minor\ error\ during\ test$$
$$c_{n2} = cost\ of\ correcting\ a\ minor\ error\ after\ release, c_{n2} > c_{n1}$$

$$c_r = cost\ of\ testing\ per\ unit\ time$$

The total cost is composed of five parts. To obtain the cost of correcting major errors during test, let N_m be the number of major errors detected during test. Then the expected value of N_m is

$$
\begin{aligned}
E[N_m] &= E[N_m|T_N > T]P\{T_N > T\} + E[N_m|T_N \le \mathrm{T}]P\{T_N \le T\} \\
&= \sum_{k=0}^{N-1} kP\{N_1(T) = k\} + NP\{N_1(T) \ge N\} \\
&= \sum_{k=0}^{N-1} k \frac{[pm(t)]^k e^{-pm(t)}}{k!} + N \sum_{k=N}^{\infty} \frac{[pm(t)]^k e^{-pm(t)}}{k!} \\
&= N + \sum_{k=0}^{N-1}(k-N)\frac{[pm(t)]^k e^{-pm(t)}}{k!}.
\end{aligned}
\tag{7}
$$

Let N_n be the number of minor errors detected during test. Then the expected value of N_n is, using a differentiation by parts,

$$
\begin{aligned}
E[N_n] &= E[N_n|T_N > T]P\{T_N > T\} + E[N_n|T_N \le \mathrm{T}]P\{T_N \le T\} \\
&= qm(T)P\{T_N > T\} + \int_0^T qm(t)dF(t) \\
&= \int_0^T q\lambda(t)P\{T_N > T\}dt \\
&= q \sum_{k=0}^{N-1} \int_0^T \lambda(t) \frac{[pm(t)]^k e^{-pm(t)}}{k!} dt.
\end{aligned}
\tag{8}
$$

Since $a = m(\infty)$ represents the expected number of total errors in the software, the expected number of major errors and minor errors remaining after release is $ap - E[N_m]$ and $aq - E[N_n]$ respectively. Therefore summing up the cost components, the expected total lifecycle cost under the proposed (N,T) policy is

$$C(N,T) = c_{m1}E[N_m] + c_{n1}E[N_n] + c_{m2}(ap - E[N_m]) + c_{n2}(aq - E[N_n]) + c_r E[T_M] \tag{9}$$

where $c_r E[T_M]$ is the cost of testing that is proportional to the testing duration.

BEHAVIOUR OF C(N,T)

The cost function $C(N,T)$ is in a complicated form of two decision variables, one of which is discrete and another is continuous. So it is not easy to obtain the optimal value of decision variables in a closed form expression.
For a fixed value of $N = 1$, the function $C(N,T)$ reduces to a simple form. Substituting $N = 1$ to (9), and differentiating with respect to T and equating it to zero, we get

$$abe^{-bT} = \frac{c_r}{(c_{m2}-c_{m1})p+(c_{n2}-c_{n1})q} \tag{10}$$

Proceedings of 2014 International Conference on
Technology Innovation and Industrial Management
28th-30th May 2014, Seoul, South Korea

which is a similar result to Okumoto and Goel (1980). Since $0 < e^{-bT} \leq 1$, the finite solution $T^* > 0$ to (10) exists if

$$\frac{c_r}{ab} < (c_{m2} - c_{m1})p + (c_{n2} - c_{n1})q. \tag{11}$$

Otherwise, the optimum value of T is $T^* = 0$.

For a fixed value of $N > 1$, differentiating (9) with respect to T and equating it to zero, we get after some algebra,

$$\frac{\sum_{k=0}^{N-2}[N-k-1+pm(T)][pm(T)]^k/k!}{\sum_{k=0}^{N-1}[pm(T)]^k/k!} + \frac{c_r}{p\lambda(T)(c_{m2}-c_{m1})} = \frac{(c_{m2}-c_{m1})Np+(c_{n2}-c_{n1})q}{(c_{m2}-c_{m1})p}. \tag{12}$$

Let $L(T)$ denote the left-hand-side of (12). Since $\lambda(0) = ab$, $\lambda(\infty) = 0$, and $m(0) = 0$ from (2) and (3), it is seen that $L(\infty) = \infty$ and

$$L(0) = N - 1 + \frac{c_r}{pab(c_{m2}-c_{m1})}. \tag{13}$$

Therefore if

$$L(0) = N - 1 + \frac{c_r}{pab(c_{m2}-c_{m1})} < \frac{(c_{m2}-c_{m1})Np+(c_{n2}-c_{n1})q}{(c_{m2}-c_{m1})p} \tag{14}$$

that is, if

$$\frac{c_r}{ab} < (c_{m2} - c_{m1})p + (c_{n2} - c_{n1})q \tag{15}$$

then there exists at least one finite solution $T^* > 0$ to (12). Notice that (15) is equivalent to (11).

CONCLUSION

In this paper, a conceptual framework was proposed for the software developer to support in deciding an optimum duration of software testing. The model involves two decision variables, one is the number of major errors detected and another is the testing time elapsed. The errors in software were classified into two types, major or minor. The expected total lifecycle cost under the proposed policy was derived with NHPP SRGM. The condition for an existence of finite value of policy variables was explored.

If the decision of software release is based solely on the testing time elapsed, it is not sure whether a sufficient number of major errors have been corrected. On the other hand, if we decide

using only with the number of errors corrected, the scheduling of the software release could be difficult because the test could last a long time passing the deadline for the software development. The policy proposed in this paper is well worth considering in that it utilizes two decision variables together which makes up for the above weaknesses.

REFERENCES

1. Bai. D., and Yun, W. (1988), "Optimum number of errors corrected before releasing a software system", *IEEE Transaction on Reliability*, Vol.37 No.1, pp.41-44.
2. Boland, P., and Chuiv, N. (2007), "Optimal times for software release when repair is imperfect", *Statistics and Probability Letters*, Vol.77, pp.1176-1184.
3. Chatterjee, S., Misra, R., and Alam, S. (1997), "Joint effect of test effort and learning factor on software reliability and optimal release policy", *International Journal of Systems Science*, Vol.28, pp.391-396.
4. Goel, A., and Okumoto, K. (1979), "Time-dependent error detection rate model for software reliability and other performance measures", *IEEE Transaction on Reliability*, Vol.28, pp.206-211.
5. Hou, R., Kuo, S., and Chang, Y. (1997), "Optimal release times for software systems with scheduled delivery time based on the HGDM", *IEEE Transaction on Computers*, Vol.46 No.2, pp.216-221.
6. Huang, C. (2005), "Optimal release time for software systems considering cost, testing-effort, and test efficiency", *IEEE Transaction on Reliability*, Vol.54, pp.583- 591.
7. Koch, H., and Kubat, P. (1983), "Optimal release time of computer software", *IEEE Transaction on Software Engineering*, Vol.9 No.3, pp.323-327.
8. Okumoto, K., and Goel, A. (1980), "Optimal release time for software system based on reliability and cost criteria", *Journal of Systems and Software*, Vol.1, pp.315-318.
9. Pham, H. (2000), *Software Reliability*, Springer, Singapore.
10. Pham, H., and Zhang, X. (2003), "NHPP software reliability and cost models with testing coverage", *European Journal of Operational Research*, Vol.145, pp.443-454.
11. Shinohara, Y., Dohi, T., and Osaki, S. (1997), "Comparison of optimal release policies for software systems", *Computers & Industrial Engineering*, Vol.33, pp.813-816.
12. Yamada, S., and Osaki, S. (1985), "Cost-reliability optimal release policies for software systems", *IEEE Transaction on Reliability*, Vol.34 No.5, pp.422-424.
13. Xie, M., and Hong, G. (1999), "Software release time determination based on unbounded NHPP model", *Computers & Industrial Engineering*, Vol.37, pp.165-168.
14. Ross, S. (1983), *Stochastic Processes*, John Wiley & Sons, New York.

BIOGRAPHY

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WEIGHTED AVERAGE OF TRIANGLE FUZZY NUMBERS

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ABSTRACT

The weighted average is widely used. In this paper, when data values and their weights are triangle fuzzy numbers, we explain to get the weighted average by algebraic approach. Three corner points of fuzzy weighted average can be obtained algebraically by simple method.

Keywords: Triangle Fuzzy numbers, Fuzzy weighted average

INTRODUCTION

Fuzzy sets theory as the foundation for a formalized logic that reflects the vagueness inherent in human reasoning was introduced originally by Zadeh [12]. The theory of fuzzy sets makes it possible to study the complex systems and ill-defined systems where uncertainty is owing to fuzziness or degree of vagueness.

On the other hand, weighted sum or weighted average is widely used, for example, multi-attribute decision making to evaluate systems [6]. Further, fuzzy multi-attribute decision making is studied various ways, for example, introducing weight factors and sensitivity analysis [7]. However, the fuzzy weighted average (FWA) is more difficult than fuzzy weighted sum.

Fuzzy weighted averages have been the topic of active research for a long time, basically well known since Bass and Kwakernak [1]. When data values and their weights are trapezoidal fuzzy numbers (TZFN), Kim [9] prove the weighted average by extension principle be a fuzzy number by analytic approach. Its 4 corner points can be obtained algebraically by simple method. In this paper triangle fuzzy numbers (TFN) are used than TZFNs.

TRIANGLE FUZZY NUMBERS AND WEIGHTED AVERAGE OF FUZZY NUMBERS

Let a real TFN $\widetilde{A} = [a_1, a_2, a_3], a_1 \le a_2 \le a_3$.

Unary and binary operations of fuzzy numbers such addition, product, opposite, and

reciprocal, can be described well using Dubois and Prade's work [4]. Addition and product are increasing functions, therefore;

$$\widetilde{A} + \widetilde{B} = [a_1 + b_1,\ a_2 + b_2,\ a_3 + b_3], \tag{1}$$

$$\widetilde{A} \cdot \widetilde{B} = [a_1 b_1, a_2 b_2, a_3 b_3], \tag{2}$$

for positive $\widetilde{A}$ and $\widetilde{B}$. Opposite and reciprocal are decreasing functions, therefore;

$$-\widetilde{A} = [-a_3,\ -a_2,\ -a_1], \tag{3}$$

$$1/\widetilde{A} = [1/a_3,\ 1/a_2\ 1/a_1]. \tag{4}$$

However, under (3) and (4), $\widetilde{A} + (-\widetilde{A}) = [a_1 - a_3,\ a_2 - a_2,\ a_3 - a_1]$ is not zero, and $\widetilde{A}/\widetilde{A} = [a_1/a_3,\ a_2/a_2,\ a_3/a_1]$ is not one. Therefore, we define fuzzy opposite number (complementary number for 0) as $-\widetilde{A} = [-a_1,\ -a_2,\ -a_3]$, and fuzzy reciprocal as $1/\widetilde{A} = [1/a_1,\ 1/a_2,\ 1/a_3]$.

When $\widetilde{A}_j$ is fuzzy rating value of a datum j, and $\widetilde{W}_j$ is fuzzy weight (positive) of a datum $i, j = 1, \cdots, m$, let $\widetilde{T}$ be FWA by $\widetilde{A}_j$ and $\widetilde{W}_j$, $j = 1, \cdots, m$.

We want to find the feature of

$$\widetilde{T} = \frac{\sum\limits_{i}^{m} \widetilde{A}_i \widetilde{W}_i}{\sum\limits_{i}^{m} \widetilde{W}_i}. \tag{5}$$

Weighted average is neither increasing nor decreasing function for weights. Dong and Wong [3] proposed an algorithm; 1) discretize the range of membership [0,1] into $\alpha_1, \cdots, \alpha_n$, 2) using supports of α-cuts of 2^{2n} distinct permutations, find $[\min z_k,\ \max z_k]$, which is the supports of α-cut of FWA.

Liou and Wong [11] improved Dong's algorithm of 2^{n+1} permutations. Really Liou and Wong's idea is similar to Kim's MD dissertation [8] that was not published in journal.

Lee and Park [10] proposed an efficient algorithm to compute FWA, which reduces the number of operations. But it is complex and sorting of initial step in algorithm also requires much operations. The max-min paired elimination method of Guh et al. [5] is similar concept to Lee and Park.

Chen et al. [2] compared the Dong and Wong's method with Juan et al.'s method. Approximation is useful when the number of rating is large, for example, $m > 11$.

Kim [9] prove the FWA of TZFNs is a FN (even though not a TZFN) and 4 corner points of FWA are obtained easily by analytic approach as follows;

$$
\left. \begin{array}{rcl}
t_1 & = & \min \left\{ \dfrac{\sum\limits_{i=1}^{m} a_{i1} w_i}{\sum\limits_{i=1}^{m} w_i}, w_i \in \{w_{i1}, w_{i4}\} \right\}, \\[2em]
t_2 & = & \min \left\{ \dfrac{\sum\limits_{i=1}^{m} a_{i2} w_i}{\sum\limits_{i=1}^{m} w_i}, w_i \in \{w_{i2}, w_{i3}\} \right\}, \\[2em]
t_3 & = & \max \left\{ \dfrac{\sum\limits_{i=1}^{m} a_{i3} w_i}{\sum\limits_{i=1}^{m} w_i}, w_i \in \{w_{i2}, w_{i3}\} \right\}, \text{ and} \\[2em]
t_4 & = & \max \left\{ \dfrac{\sum\limits_{i=1}^{m} a_{i4} w_i}{\sum\limits_{i=1}^{m} w_i}, w_i \in \{w_{i1}, w_{i4}\} \right\}.
\end{array} \right.
\tag{6}
$$

For TFN, $t_2 = t_3$ in (6),

$$\left|
\begin{array}{l}
t_1 = \min \left\{ \dfrac{\sum\limits_{i=1}^{m} a_{i1} w_i}{\sum\limits_{i=1}^{m} w_i}, w_i \in \{w_{i1}, w_{i3}\} \right\}, \\[2em]
t_2 = \left\{ \dfrac{\sum\limits_{i=1}^{m} a_{i2} w_{i2}}{\sum\limits_{i=1}^{m} w_{i2}} \right\}, \text{ and} \\[2em]
t_3 = \max \left\{ \dfrac{\sum\limits_{i=1}^{m} a_{i3} w_i}{\sum\limits_{i=1}^{m} w_i}, b_i \in \{w_{i1}, w_{i3}\} \right\}.
\end{array}
\right. \tag{7}$$

EXAMPLE

There are fuzzy values of 3 factors, $\widetilde{A_1}$ = [.5, .7, .9], $\widetilde{A_2}$ = [.4, .6, .8] and $\widetilde{A_3}$ = [.7, .8, .95], with fuzzy weights, $\widetilde{W_1}$ = [.4, .7, .9], $\widetilde{W_2}$ = [.3, .4, .6], and $\widetilde{W_3}$ = [.1, .2, .3].

Then FWA $\widetilde{T}$ = [.4636, .6538, .89] as shown in grayed column of Table 1.

Table 1. Calculations of 4 Corner Points

	Required a_i, w_i	Combinations, $\dfrac{\sum a_i w_i}{\sum w_i}$	FWA	Wrong case assuming increasing function of w	Wrong case assuming decreasing function of w
t_1	a_{11} =.5 a_{21} =.4 a_{31} =.7 w_1 ={.4, .9} w_2 ={.3, .6} w_3 ={.1, .3}	.4875 .53 .4636 .5 .4923 .52 .475 .5	→min{ }= .4636	→.4875	→ .5
t_2	a_{12} =.7 a_{22} =.5 a_{32} =.8 w_{12} =.7 w_{22} =.4 w_{32} =.2	.6538	same to left	same to left	same to left

	Required a_i, w_i	Combinations, $\dfrac{\sum a_i w_i}{\sum w_i}$	FWA	Wrong case assuming increasing function of w	Wrong case assuming decreasing function of w
t_3	$a_{13} = .9$ $a_{23} = .8$ $a_{33} = .95$ $w_1 = \{.4, .9\}$ $w_2 = \{.3, .6\}$ $w_3 = \{.1, .3\}$	.8688 .885 .85 .8654 .8808 .89 .8656 .875	→max{ }= .89	→ .875	→ .8688

However, the calculation result assuming the weighted average be an increasing function of weights is [.4875, .6538, .875] that is used commonly (left by left, right by right) without exact extension principle, and assuming decreasing function, the result is [.5, .6538, .8638] as shown in Table 1. They are slightly less fuzzy than $\widetilde{T}$.

On the other hand, the sequential calculation by product, sum, then division leads wrong result as follows:

$$\sum_i^m \widetilde{A}_i \widetilde{W}_i = [.39, .85, 1.575],$$

$$\sum_i^m \widetilde{W}_i = [.8, 1.3, 1.8],$$

$$\widetilde{C} = 1 / \sum_i^m \widetilde{W}_i = [1/1.8, 1/1.3, 1/.8], \text{ and}$$

$$\left(\sum_i^m \widetilde{A}_i \widetilde{W}_i \right) \widetilde{C} = [.2167, .6538, 1.9688]. \tag{8}$$

This (8) is fuzzified too much than $\widetilde{T}$. In this example, the weighted average must be in [0,1], but the maximum point is over 1. Furthermore, three points must be between the minimum and maximum points of $\widetilde{A}_j$'s (that is .4 to.95), but this result is out of bound.

CONCLUSIONS

FWA is an important research topic because of wide uses. In this paper we explain to get FWA of TFNs, where three corner points of FWA can be obtained algebraically by simple method as (7).

REFERENCES

1. Baas, S.M., and H. Kwakernak, Rating and ranking of multiple aspect alternatives using fuzzy sets, *Automatica* **13** (1977) 47-58.
2. Chen, H.K., W.K. Hsu and W.L. Ching, A Comparison of the vertex method with JHE method, *Fuzzy Sets and Systems* **95** (1998) 201-214.
3. Dong, W.M., and F.S. Wong, Fuzzy weighted averages and implementation of the extension principle, *Fuzzy Sets and Systems* **21** (1987) 183-199.
4. Dubois, D., and H. Prade, *Fuzzy Sets and Systems* (Academic Press, 1980).
5. Guh, Y.Y., C.C. Hong, K.M. Wang and E.S. Lee, Fuzzy weighted average: a max-min paired elimination method, *Computers Math. Applic.* **32** (1996) 115-123.
6. Hwang, C.L., and K. Yoon, *Multiple Attribute Decision Making: Method and Applications* (Springer Verlag, 1981).
7. Kaymak, U., and H.R. van Nauta Lemke, A sensitivity analysis approach to introducing weight factors into decision functions in fuzzy multicriteria decision making, *Fuzzy Sets and Systems* **97** (1998) 169-182.
8. Kim, K., *System Evaluation Using Fuzzy Checklist*, Master Degree Dissertation (KAIST, Korea, 1987)
9. Kim, K., Weighted Average of Fuzzy Numbers, *Journal of the Korea Management Engineers Society* **17.3** (2012) 161-168.
10. Lee, D.H., and D. Park, An Efficient algorithm for fuzzy weighted average, *Fuzzy Sets and Systems* **87** (1997) 39-45.
11. Liou, T.S., and M.J. Wang, Fuzzy weighted average: an improved algorithm, *Fuzzy Sets and Systems* **49** (1992) 307-317.
12. Zadeh, L.A., Fuzzy sets, *Information & Control* **8** (1965) 338-353.

META-HEURISTIC ALGORITHM FOR SOLVING VEHICLE ROUTING PROBLEM WITH TIME WINDOWS

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ABSTRACT

This paper deals with the vehicle routing problem with time windows (VRPTW). The VRPTW routes a set of vehicles to service customers having earliest, latest service times. The demands are served by capacitated vehicles with limited travel times to return to the depot. The purpose of this paper is to develop an algorithm that uses the modified push forward insertion heuristic (MPFIH), a λ-interchange local search descent method (λ-LSD) and a genetic algorithm to solve VRPTW with multiple objectives. The first objective aims to determine the minimum number of vehicles needed and the other is find the solution that minimize the total travel times. A set of well-known benchmark problem are used to compare the quality of solutions. The results show that the proposed algorithm provides effective solution compared with best found solutions and better than the other heuristic used for the comparison.

Keywords: Vehicle routing problem with time Windows (VRPTW), Genetic algorithm

INTRODUCTION

The vehicle routing problem (VRP) belongs to the class of *NP*-hard combinatorial problems which require substantial amount of time to determine optimal solutions for large problems. The fundamental objectives are to specify the minimum number of vehicles, the minimal travel time or the minimal costs of the travelled routes. However, in real world applications, the VRP is extended by constraints such as vehicle capacity or time interval in which each customer must be visited. Thus, this VRP becomes the capacitated vehicle routing problem with time windows (VRPTW). This paper proposes an algorithm with multiple objectives of minimizing the number of vehicles and minimizing the total travel time for the VRPTW. First, the modified push forward insertion heuristic (MPFIH) is used to generate an initial solution and then the solution

is improved by a λ-interchange local search descent method (λ-LSD) combined with a genetic algorithm. The constraints of the problem are to service all the customers within the earliest and latest service time of the customer without exceeding the route time of the vehicle and overloading the vehicle. The route time of the vehicle is defined as the sum of the waiting times, the service times and the travel times. A vehicle that reaches a customer before the earliest time, after the latest time and after the maximum route time incurs waiting time, tardiness time and overtime, respectively. Finally, the total of the customer demands in each route cannot exceed the total capacity of the vehicle.

The rest of this paper is organized as follows. Section 2 reviews relevant VRPTW and algorithms. Section 3 presents the methodology to solve this problem. Section 4 presents the results and discussion. Finally, conclusions and future work are discussed in section 5.

LITERATURE REVIEW

The VRPTW is a well-known and complex combinatorial problem with considerable economic significance [2]. Savelsbefgh [12] has shown that finding a feasible solution to the traveling salesman problem with time windows (TSPTW) is a *NP*-complete problem. Thus, the VRPTW is more complex as it considers servicing customers with time windows using multiple vehicles. Although, optimal solutions to the VRPTW can be obtained using exact methods, the computational time required to solve a VRPTW optimally is prohibitive for large problems [5]. As a result, heuristic methods are often used to obtain optimal or near optimal solution in a reasonable amount of time. Heuristic approaches for the VRPTW use route construction, route improvement or methods that integrate both route construction and route improvement. Solomon [13] designed and analyzed a number of route construction heuristic, namely: the savings, time-oriented nearest neighbor insertion and a time oriented sweep heuristic for solving the VRPTW. In his study, the time-oriented nearest neighbor insertion heuristic has shown to be very successful. Berger and Barkaoui [2] proposed a parallel version of a hybrid genetic algorithm for VRPTW. This approach is based on the simultaneous evolution of two populations of solution focusing on separate objectives subject to temporal constraint relaxation. Bräysy and Gendreau [3, 4] presented a survey of the research on the VRPTW. Both traditional heuristic route construction methods and recent local search algorithms are examined in Part I. Part II gives an overview of meta-heuristic approaches for the VRPTW. Baker and Aey applied a genetic algorithm to the basic vehicle routing problem.

Recently, several researches involve algorithms to solve the multi-objective VRPTW. Ombuki *et al*. [10] presented a genetic algorithm solution using the Pareto ranking technique. An

advantage of this approach is that it is unnecessary to derive weights for a weighted sum scoring formula. Tan *et. al.* [15] proposed a hybrid multi-objective evolutionary algorithm (HMOEA) with specialized genetic operators and variable length chromosome representation to accommodate the sequence-oriented optimization in VRPTW. The HMOEA optimizes all routing constraints and objectives simultaneously, which improves the routing solutions in many aspects, such as lower routing cost, wider scattering area and better convergence trace. Ghoseiri and Ghannadpour [7] developed an evolutionary algorithm for the VRPTW by incorporating various heuristics for local exploitation in the evolutionary search and the concept of Pareto's optimality. Garcia-Najera and Bullinaria [6] propose an improved multi-objective evolutionary algorithm for the VRPTW by adding a measure of similarity between solutions. Also other conflicting objectives may be taken into account in the VRPTW. All approaches in the literature are quite effective, as they provide solutions competitive with the well-known benchmark data of Solomon's VRPTW instances [14].

METHODOLOGY

Notation
K: total number of vehicles, with index, $k = 1,..., K$

K_{LB}: lower bound of the number of vehicles, where $K_{LB} = \dfrac{\sum_{i=2}^{N} d_i}{q_k}$

N: total number of customers, including the depot
C_i: customer i, where $i = 2,..., N$
C_1: depot
d_i: demand of customer i
D_k: total demand for the vehicle k
q_k: capacity of vehicle k
t_{ij}: travel time between customer i to customer j where $i, j = 1, ..., N, i \neq j$ and $i, j = 1$ is depot
e_{ik}: earliest arrival time of vehicle k at customer i
l_{ik}: latest arrival time of vehicle k at customer i
A_{ik}: arrival time of vehicle k to customer i
b_i: service time at customer i
w_{ij}: waiting time between customer i and j where
$w_{ij} = \max[e_j - (A_i + t_{ij}), 0]$, $i, j = 2,..., N$ and $i \neq j$
M_k: maximum route time, where $k = 1,..., K$
R_k: vehicle route k, where $k = 1,..., K$
W_k: total waiting time for vehicle k, where $k = 1,...,K$

B_k: total service time for vehicle k, where $k = 1,...,K$
O_k: total overtime for vehicle k, where $k = 1,..., K$
L_k: total tardiness for vehicle k, where $k = 1,..., K$
T_k: total travel time for vehicle k, where $k = 1,..., K$
Tot_k: total travel time for vehicle k, or
$Tot_k = T_k + W_k + B_k$ where $k = 1,..., K$
α: penalty weight factor for the waiting time
γ: penalty weight factor for the tardiness time
η: penalty weight factor for the overtime

Algorithm

We consider a set of vehicles, K, and a set of customer nodes, C_i. We identify C_1 as the depot node and $C = C_i + C_1$ represent the set of all nodes. Let x be the set of the decision variables, they are evaluated using the function, $F(x)$, as equation (1):

$$F(x) = T_k + (\alpha \times W_k) + (\gamma \times L_k) + (\eta \times O_k) \quad (1)$$

Typically, we would like to route vehicles such that the total travel time of all vehicles and their penalties are, $F(x)$, are minimized

In this section, a two-phase algorithm for solving the VRPSTW is developed. The algorithm consists of two phases, a route construction phase and a route improvement phase. In the first phase, a modified push-forward insertion heuristic (MPFIH) is applied. The MPFIH developed by Manisri *et. al.* [9] is a heuristic method for inserting a customer into a route based on the push-forward insertion method of Solomon [13] and Thangiah [15][16]. It is an efficient method for computing the insertion of a new customer into the route. Let us assume a route $R_k = \{C_{ik},...,C_{mk}\}$ where C_{ik} is the first set of customers and C_{mk} is the last set of customers in each route k. The earliest arrival and latest arrival time are defined as e_{ik}, l_{ik} and e_{mk}, e_{lk}, respectively. The number of routes in this method is defined as the minimum number of vehicles necessary to satisfy total customer demand. The feasibility of inserting a set of customers into route R_k is checked by inserting the customer between all edges in the current route and selecting the edge that satisfies the vehicle capacity. The MPFIH algorithm is shown below.

Step 1: Sort the customer nodes which have e_i and l_i in ascending and descending order, respectively
Step 2: Construct the initial matrix, R_k, where $k = K_{LB}$
Step 3: Construct the set of C_{ik} and C_{mk} which the first k minimum, e_i and the first k maximum, l_i, respectively

Step 4: Remove the customer nodes that have been selected to matrix, R_k

Step 5: Select the set of C_{ik} which the next k minimum, e_i

Step 6: Check the feasible routes, each row of matrix, R_k that satisfy the constraints,

$$D_k = \sum_{i=l}^{m} d_i \leq q_k, \; Tot_k \leq M_k \text{ and } L_k = 0$$

If all rows satisfy the constraints, go to step 7, else go to step 9

Step 7: Insert the set of C_{ik} between set of C_{lk} and C_{mk} then repeat step 4 to step 6

Step 8: If all of set C_{ik} has been inserted to routes or matrix, R_k then the algorithm terminates, else go to step5

Step 9: Select the remainder, C_i which the next minimum, e_i

Step 10: Check the feasible routes, each the remainder row of matrix, R_k that satisfy the constraints, $D_k = \sum_{i=l}^{m} d_i \leq q_k$, $Tot_k \leq M_k$ and $L_k = 0$. If the remainder rows satisfy the constraints go to step 11, else go to step 14

Step 11: Insert C_i in the remainder routes or rows of matrix, R_k

Step 12: Remove the customer nodes that have been selected and then repeat step 9 to step 12

Step 13: If all of C_i has been inserted to routes or matrix, R_k then the algorithm terminates, else go to step 14

Step 14: Construct a new route or row of matrix, R_{k+i}, where $i = 1,2,...,n$ and then repeat step 9 to step 13

In the second phase, the route improvement algorithm applies local search and a genetic algorithm, based on the concept of iteratively improving the solution to a problem by exploring neighboring ones. To design a λ-interchange local search descent method (λ-LSD), one typically needs to specify the following choices: how an initial feasible solution is generated, what move-generation mechanism to use, the acceptance criterion and the stopping criterion [3]. The λ-LSD searches the set of all neighbors generated by the LSD for a given integer λ equal to 1 and 2. The move generation mechanism creates the neighboring solutions by the move operators (0, 1), (1, 0), (1, 1), (0, 2), (2, 0), (1, 2), (2, 1) and (2, 2). The operator (0, 1) on routes (R_p, R_q) indicates a shift of one customer from route q to route p (Fig. 1). The operators (0, 1), (1, 0), (2, 0) and (0, 2) indicate a shift of one or two customers between two routes. The operators (1, 1), (1, 2), (2, 1) and (2, 2) indicate an exchange of one or two customers between two routes (Fig. 2).

It is a sequential search which selects all possible combinations of different pair of routes. The first generation mechanism has been introduced by Osman and Christofides [10]. If the neighboring solution is better, it replaces the current solution and the search continues. The

acceptance strategy, the first best (FB) is used to select the first neighbor that satisfies the pre-defined acceptance criterion.

Fig. 1 The move operator (0, 1)

Fig. 2 The move operator (1, 2)

Then the genetic algorithm [1] is applied to prevent the local search falling into a local optimum. The GA based algorithm for the VRPTW can be summarized as follows:

Step 1: Construct travel time matrix using Euclidean distances.
Step 2: Set the penalty weight factor parameters: $\alpha = 0.01$, $\gamma = 0.1$ and $\eta = 0.05$
Step 3: Set the parameters for the λ-LSD and GA, the number of iterations =100, the number of initial populations = 100, crossover rate, $P_c = 0.7$ and mutation rate, $P_m = 0.3$.
Step 4: Generate initial population $F(x, t_{sb})$; $x \in X$ using MFPIH
Step 5: Evaluate fitness functions of initial populations
Step 6: Select parent chromosome using roulette wheel selection.
Step 7: Generate random number for the crossover and mutation in each iteration
   7.1 If the random number is less than P_c, choose the crossover.

7.2 If the random number is less than P_m, choose the mutation.

Step 8: Evaluate fitness functions of offsprings

Step 9: Increase the number of offsprings in the initial solutions and calculate the probabilities in choosing the chromosome.

Step 10: Repeat step 5 - 9 until the stopping criterion is found.

The performance of the algorithm is measured by the quality of the solution which is compared with the best found solution published in literature.

RESULTS AND DISCUSSION

In step 7, we need to identify appropriate levels of P_c and P_m. So, P_c between 0.1 to 0.9 and P_m between 0.1 to 0.9 have been evaluated using Solomon's benchmark problems, C1&C2, R1&R2 and RC1&RC2 as shown in Table 1.

Table 1: Comparison of Distance with Different Probabilities of Crossover and Mutation

Probability Level of Crossover and Mutation	Minimum Distance					
	C1	C2	R1	R2	RC1	RC2
(0.9, 0.1)	2238	5656	1218	1594	2238	5656
(0.8, 0.2)	2005	6567	1186	1609	2005	6567
(0.7, 0.3)	2124	5273	1115	1682	2124	5273
(0.6, 0.4)	1948	5319	1179	1554	1948	5319
(0.5, 0.5)	1831	6222	1259	1836	1831	6222
(0.4, 0.6)	1924	6362	1248	1796	1924	6362
(0.3, 0.7)	1898	5509	1154	1776	1898	5509
(0.2, 0.8)	1928	7332	1261	1617	1928	7332
(0.1, 0.9)	2001	6658	1195	1614	2001	6658

Next, we analyzed the results from the GA using the ANONVA technique. The results have shown that there is no significance in choosing the probability levels for the crossover and

mutation. As a result, researchers are free to choose any values for the crossover and mutation. Table 2 shows only the ANOVA result for problem R2 only.

Table 2: ANOVA Analysis for R2 Problem

Source of Variation	SS	df	MS	F	P-value
Between Groups	65,882	2	32,941	2.86	0.076
Within Groups	276,360	24	11,514		
Total	342,242	26			

The algorithm is tested on 2 types of Solomon's VRPTW benchmarking problems including R1 and R2. The experiment runs on 23 VRPTW instances. All instances have 25, 50 or 100 customer nodes and a single depot node. The solutions have been compared with the solutions from Manisri *et al*. [9] as shown in Table 3.

Table 3: Results for Problem R1

Problem R1	No. of Cities	Best Found Solution		Hybrid Algorithm		GA Based Algorithm	
		NV	TT	NV	TT	NV	TT
R101	25	8	617	7	613	5	502
	50	12	1044	12	1155	7	811
	100	19	1646	17	1916	17	1543
R102	25	7	547	5	494	4	450
	50	11	909	9	932	6	756
	100	17	1486	17	1694	14	1387
R103	25	5	454	5	498	3	417
	50	9	772	8	823	7	711
	100	13	1293	15	1467	14	1410
R104	25	4	416	4	417	3	421
	50	6	625	7	698	6	663
	100	9	1007	13	1199	10	1331

Problem R1	No. of Cities	Best Found Solution		Hybrid Algorithm		GA Based Algorithm	
		NV	TT	NV	TT	NV	TT
R105	25	6	530	6	553	5	490
	50	9	899	10	957	7	745
	100	14	1377	18	1608	13	1334
R106	25	3	465	5	494	4	424
	50	5	793	8	872	6	701
	100	12	1252	15	1452	15	1370
R107	25	4	424	5	487	4	431
	50	7	711	8	793	6	676
	100	10	1105	14	1298	10	1218
R108	25	4	397	4	427	3	421
	50	6	617	7	679.1	6	647
	100	9	961	11	1054	10	1351
R109	25	5	441	5	486	4	429
	50	8	786	8	867	5	723
	100	11	1195	15	1341	14	1340
R110	25	4	444	4	433	3	399
	50	7	697	8	789	7	695
	100	10	1119	15	1305	11	1186
R111	25	5	428	4	471	4	413
	50	7	707	8	755	5	659
	100	10	1097	13	1218	12	1205
R112	25	4	393	4	406	3	401
	50	6	630	7	767	6	640
	100	9	982	12	1144	10	1248

Table 3: Solutions for Problem R2

Problem R2	No. of Cities	Best Found Solution		Hybrid Algorithm		GA Based Algorithm	
		NV	TT	NV	TT	NV	TT
R201	25	4	463	3	577	2	487
	50	6	792	7	1164	6	827
	100	4	1252	11	1967	12	1439
R202	25	4	411	4	536	4	445
	50	5	699	7	1083	5	745
	100	3	1191	8	1683	10	1333
R203	25	3	391	2	468	2	459
	50	5	605	4	822	4	764
	100	3	939	8	1408	5	1218
R204	25	2	355	2	443	1	592
	50	2	506	2	619	2	593
	100	2	825	6	1080	5	1116
R205	25	3	393	N/A	N/A	1	612
	50	4	690	5	896	5	765
	100	3	994	8	1468	10	1292
R206	25	3	374	3	514	3	455
	50	4	632	4	897	5	712
	100	3	906	8	1369	8	1284
R207	25	3	362	2	457	2	381
	50	N/A	N/A	2	696	4	633
	100	2	893	3	1025	6	1271
R208	25	1	328	N/A	N/A	1	564
	50	N/A	N/A	3	644	3	576
	100	2	726	3	862	4	1024
R209	25	2	371	2	453	2	406
	50	4	601	4	751	4	757
	100	3	909	8	1359	7	1172
R210	25	3	405	2	513	2	405
	50	4	646	3	768	5	681
	100	3	939	6	1283	8	1274
R211	25	2	351	2	424	2	370
	50	3	536	3	637	2	678
	100	2	892	6	1028	5	1075

Note that NV and TT represents the number of vehicles and the total travel time, respectively. The results in Table 3 and 4 are summarized in Table 5 to compare efficiency of each algorithm.

Also Note that BFS is best found solution, HY represents the Manisri algorithm, and GA is the proposed method in this paper.

From Table 3 to 5 illustrate the result of the proposed algorithm is effective, as it provides solutions competitive with best solutions and better solutions than those obtained by HY. There are some new solutions that better than Solomon problem instances.

Table 5: Summary of Solutions

Problem	Result		Number of Customers			
			25	50	100	All
R1	BFS	NV	4.92	7.75	13.08	8.58
		TT	463	766	1178	802
	HY	NV	4.83	8.33	14.58	9.25
		TT	482	840	1391	904
	GA	NV	3.75	6.17	12.50	7.47
		TT	433	702	1326	820
R2	BFS	NV	2.98	4.11	3.09	3.34
		TT	381	634	941	672
	HY	NV	2.44	4.33	6.82	4.69
		TT	487	848	1321	915
	GA	NV	2.15	4.26	7.71	4.71
		TT	467	702	1235	801

CONCLUSION AND FUTURE WORK

An algorithm to solve the multi-objective VRPTW has been developed using the concept of modified push forward insertion heuristic (MPFIH), a λ-interchange local search descent method (λ-LSD) and a genetic algorithm. The effectiveness of the proposed algorithm is evaluated through the use of Solomon benchmark problem. The results show that the proposed algorithm provides effective solutions compared with best found solutions and better than the other heuristic used for the comparison.

For the future work, we will complete the comparison with all Solomon benchmark problems. We will also improve this proposed algorithm using simulated annealing. We will also apply this proposed algorithm for the robust optimization for VRPTW.

REFERENCES

1. B. Baker, M. Ayechew, "A genetic algorithm for the vehicle routing problem", Computers and Operations Research", Vol. 30, pp. 787-800, 2003

2. J. Berger and M. Barkaoui, "A parallel hybrid genetic algorithm for the vehicle routing problem with time windows", Computers and Operations Research, Vol. 31, pp. 2037-2053, 2004

3. O. Bräysy and M. Gendreau, "Vehicle routing problem with time windows, Part I: Route construction and local search algorithms", Transportation Science, Vol. 39 (1), pp.104-118, 2005a

4. O. Bräysy and M. Gendreau, "Vehicle routing problem with time windows, Part II: Metaheuristics", Transportation Science, Vol. 39 (1), pp.119-139, 2005*b*

5. J. F. Cordeau, M. Gendreau, G. Laporte, J. Y. Potvin and F. Semet, "A guide to vehicle routing heuristics", Journal of the Operational Research Society, Vol. 53, pp.512-522, 2002

6. A. Garcia-Najera and J.A. Bullinaria, "An improved multi-objective evolutionary algorithm for the vehicle routing problem with time windows", Computers & Operations Research, Vol. 38, pp.287-300, 2011

7. K. Ghoseiri and S.F. Ghannadpour, "Multi-objective vehicle routing problem with time windows using goal programming and genetic algorithm", Applied Soft Computing, Vol. 10, pp.1096-1107, 2010

8. N. Jozefowiez, F. Semet and E. Talbi, "Multi-objective vehicle routing problems", European Journal of Operational Research, Vol. 189, pp.293-309, 2008

9. T. Manisri, A. Mungwattana, and G. K. Janssens, "Algorithm for the Mult-objective Vehicle Routing Problem with Time Windows", The 5th International Congress on Logistics and Supply Chain Management Systems, 2009, Soul, South Korea

10. B. Ombuki, B. J. Ross and F. Hanshar, "Multi-objective genetic algorithms for vehicle routing problem with time windows", Applied Intelligence, Vol 24 (1), pp. 17-30, 2006.

11. I. H. Osman and N. Christofides, "Capacitated clustering problems by hybrid simulated annealing and tabu search", International Transactions in Operational Research, Vol. 1(3), pp. 317-336, 1994

12. M. W. P. Savelsbergh, "Local search for routing problems with time windows", Annals of Operations Research, Vol. 4 (1-4), pp.285-305, 1985

13. M. M. Solomon, "Algorithms for the vehicle routing and scheduling problems with time windows constraints", Operations Research, Vol. 35 (2), pp.254–265, 1987

14. M. M Solomon, "VRPTW benchmark problems", Available Source:

15. http://web.cba.neu.edu/~msolomon/problems.htm, March 24, 2008.

**Proceedings of 2014 International Conference on
Technology Innovation and Industrial Management
28th-30th May 2014, Seoul, South Korea**

16. K. C. Tan, Y. H. Chew and L. H. Lee, "A hybrid multiobjective evolutionary algorithm for solving vehicle routing problem with time windows", Computational Optimization and Applications, Vol. 34(1), pp.115-151, 2006

17. S. R. Thangiah, "A Hybrid Genetic Algorithms, Simulated Annealing and Tabu Search Heuristic for Vehicle Routing Problems with Time Windows", Practical Handbook of Genetic Algorithms, Vol.3: Complex Structures, L. Chambers (Ed.), CRC Press, pp.347-381, 1999

18. S. R. Thangiah, J. Y. Potvin and S. Tong, "Heuristic approaches to vehicle routing with backhauls and time windows", Computers and Operations Research, Vol. 23(11), pp.1043-1057, 1996

CONSTRUCTING A NOVEL MONOTONICITY CONSTRAINED SUPPORT VECTOR REGRESSION MODEL

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ABSTRACT

This paper aims to construct a monotonicity constrained nonlinear regression model based on Support Vector Machines (SVMs). In many application areas of machine learning, there exists prior knowledge concerning the monotone relations between the response variable and some of the predictor variables. Monotonicity may be an important model requirement with a view toward explaining and justifying decisions. Therefore, in the study we propose a monotonicity constrained Support Vector Regression (SVR) model that incorporates in the monotone nature of the problems. A quadratic programming problem in the dual space is developed similar to its SVR predecessor. When applied to some synthetic data sets, the proposed method shows advantages and promising results.

Keywords: Classification problems, SVM, Monotonicity constraints

INTRODUCTION

Data mining techniques enable us to discover hidden patterns and extract valuable knowledge from databases. With the advent of the computer, various data mining methods have been proposed and vehemently discussed. Among them, support vector machines (SVM), characterized by convex optimization problems, is an important method in the fields of neural networks and nonlinear modeling, and has been successfully applied to problems of classification and nonlinear function estimation. The technology of SVM, pioneered by Vapnik in 1995, is a state-of-the-art artificial neural network (ANN) based on statistical learning (Vapnik, 1995; Vapnik, 1998). In recent years, it has drawn overwhelming attention from diverse research communities due to its outstanding performance to solve classification problems and its novel approach to improve the generalization property of ANNs (Burges, 1998; Cristianini & Shawe-Taylor, 2000). Unlike ANNs which minimize empirical risk, SVM is designed to minimize the structural risk by minimizing an upper bound of the generalization error rather than the training error. Therefore, the over fitting problem in machine learning can be solved successfully. Compared to ANNs, the other outstanding property of SVM is that the task of training SVM can be mapped to a uniquely solvable linearly constrained quadratic programming problem, which produces a solution that is always unique and globally optimal. SVMs have been widely applied to many kinds of fields in the past few years, such as corporate distress, consumer loan evaluation, text categorization, handwritten digit recognition, speaker verification, bioinformatics, and many others.

In many applications of classification, we have a priori knowledge to the extent that, all else being equal, an increase in an input variable should not lead to a decrease (or increase) in class label. For example, if loan applicants A and B have the same attribute values, except that A has a higher income than B, then it would be surprising if B got the loan while A did not. Examples of other application domains in which we can have this type of knowledge are legal support systems, medicine (e.g. smoking increases the probability of vascular diseases), operations research and economics (e.g. house prices increase with the house area). In the aforementioned problems, one can see that there are some monotonic relationships between the class and some of the attributes. When taking into account this prior knowledge about the data, one needs to add some monotonicity constraints into the classification model like SVM. It has been shown that classification technique incorporated with monotonicity constraints can extract knowledge with more justifiability and comprehensibility.

In the data-mining literatures about monotonicity constraints, there are two different approaches for dealing with problems that have prior knowledge of monotonic properties, although there are only few papers focused on this topic. One is to apply a relabeling technique to those data missing monotonicity (Duivesteijn & Feelders, 2008). The other is to add the monotonicity constraints directly to the optimization modeling settings (Falck *et al.*, 2009; Evgeniou & Boussios, 2005; Doumpos & Zopounidis, 2009), In the latter approach,

Evgeniou, Boussios and Zcharia (Evgeniou & Boussios, 2005) and Doumpos and Zopounidis (Doumpos & Zopounidis, 2009) simulated a mass of monotonic data to formulate monotonicity constraints to enforce monotonicity. One can see that the simulated data could increase the complexity of the problem computation-wise. Pelckmans et al. developed a LS-SVM regression model with monotonicity constraints. In their problems settings, instead of using simulated data, the input data are all utilized to formulate the monotonicity constraints, and they assume the input data follow a linear order and the bias term is omitted. However, such assumption may not be applied in practice. Moreover, the sparseness is lost in the LS-SVM regression model. Therefore, to deal with the shortcomings caused in the aforementioned studies, in this research, we propose a new SVR model with monotonicity constraints that are inequalities and are based on the partial order in the input data.

The rest of the paper This paper is organized as follows. In Section 2, we have the related literature review. In Section 3, we discuss formulation of the monotonicity constrained SVMR model. Section 4 presents the experimental results. And finally, in Section 5, we have discussion and conclusion.

LITERATURE REVIEW

In this section, we review the related literatures to lay the foundation of this research project. The topics include support vector machines and classification with monotonicity constraints.

Support Vector Machines

SVM is the state-of-the-art neural network technology based on statistical learning (Vapnik, 1995; Vapnik, 1998). It was originally designed for binary classification in order to construct an optimal hyperplane so that the margin of separation between the negative and positive data set will be maximized. If the data are linearly separated, the optimal hyperplane will separate the data without error and the data points closest to the optimal separating hyperplane are named as support vectors. However, in practice, the data set of interest is usually linear nonseparable. In order to enhance the feasibility of linear separation, one can usually perform a non-linear transformation to the data set into a higher dimensional space, the so-called feature space. Unfortunately, the curse of dimensionality in machine learning makes the non-linear mapping too difficult to solve. SVMs solve the hurdle by using the mechanism of inner-product kernel.

A comprehensive tutorial on SVM classifier has been published by Burges (1998) (Burges, 1998). Excellent performances were also obtained in the function estimation and time-series prediction applications (Müller et al., 1997; Mukherjee et al., 1997). Huang, Nakamoria, Wang (2005) (Huang et al., 2005)investigated the predictability of financial movement direction with SVM by forecasting the weekly movement direction of NIKKEI 225 index. They demonstrated that SVM outperforms Linear Discriminant Analysis, Quadratic Discriminant Analysis and Elman Backpropagation Neural Networks. Recently, SVM has

received much more attractions than the traditional backpropagation neural network attributed to its salient advantages (Kim & Sohn, 2010). With the advantages, many studies on SVM are presented in multiple disciplinary concerning its theory and applications.

Classification with Monotonicity Constraints

For classification problems with ordinal attributes very often, the class attribute should increase with each or some of the explaining attributes. They are called classification problems with the monotonicity constraints (Potharst & Feelders, 2002). The problem of classification with monotonicity constraints are commonly encountered in real-life applications such as bankruptcy risk prediction (Greco et al., 1998), finance (Gamarnik, 1998), breast cancer diagnosis (Ryu et al., 2007), house pricing (Potharst & Feelders, 2002), credit rating (Doumpos & Pasiouras, 2005) and many others. The importance of classification with monotonicity constraints had been witnessed by (Pazzani et al., 2001), which presented an evaluation work to investigate the potential for monotonicity constraints to bias machine learning systems to learn rules that were both accurate and meaningful. M. Doumpos, C. Zopounidis (Doumpos & Zopounidis, 2009) proposed a monotonic support vector machines for credit risk rating. It use the monotonicity "hints" to produce the virtual examples to impose the monotonic conditions which represent the special prior domain knowledge of the problem. The experimental results from a large sample of Greek industrial firms demonstrated that the introduction of the monotonicity condition reduces the danger of overfitting, thus leading to models with higher predicting ability. S. Wang applied the neural network with monotonicity property as a non-parametric efficiency analysis method to the study of efficiency analysis for private and public organizations (Wang, 2003). Simulation experiments demonstrated that their approach can remove the overhead about the parametric assumption of distribution functions as traditional efficiency analysis such as data envelopment analysis (DEA) and stochastic frontier functions (SFF). Similar work can be seen in (Pendharkar and Rodger, 2003) (Pendharkar & Rodger, 2003). Daniels and Kamp (1999) (Daniels & Kamp, 1999) proposed a monotonic neural network whose construction was done by considering multilayer neural networks with non-negative weights.

In the literature we surveyed, there is a lack of method for constructing SVM with monotonicity constraints. With the increasingly more popularity ofSVM over traditional classification methods, our study isexpected to able to fulfill the need for a monotonic SVM.

RESEARCH METHODOLOGY

In this section, we describe the formulation of the proposed monotonicity constrained SVM model.

Monotonicity is a relationship in which increasing the value of the variables always increases or decreases the likelihood category membership. Monotonicity is defined as

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Technology Innovation and Industrial Management
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follows:

Let N be the number of instances, and n be the number of attributes. Given a dataset

$\mathfrak{I} = \{(x_i, y_i)|i = 1,2, \dots, N\}$, with denoted as the feature space, and a partial ordering $\leq$ defined over this input space R^n. A linear ordering $\leq$ is defined over the space Y of class values y_i . Then the classifier is monotoneif the following statement holds:

$$x_i \leq x_j \Rightarrow f(x_i) \leq f(x_j), \forall i, j \qquad (1)$$

A a partial ordering $\leq$ on a set A is a relation $\leq \subset A \times A$ which satisfies three properties containing reflexivity, anti-symmetry, and transitivity. A linear ordering is a partial order with comparability. These properties are described in the following.

Reflexivity: $a \leq a$ for all $a \in A$

Anti-symmetry: If $a \leq b$ and $b \leq a$ for any $a, b \in A$, then $a = b$

Transitivity: If $a \leq b$ and $b \leq c$ for any $a, b, c, \in A$, then $a \leq c$

Comparability: For any $a, b \in A$, either $a \leq b$ or $b \leq a$

For a set of observed dataset $\{(x_i, y_i)|i = 1,2, \dots, N\}$, the primal SVR model can be presented as

$$\min_{w,b.e} j(w, e) = \frac{1}{2} w^t w + C \sum_{k=1}^{N} (e_k + e_k^*)$$

Subject to $\begin{cases} y_k - (w^t \varphi(x_k) + b) \leq \varepsilon + e_k \\ (w^t \varphi(x_k) + b) - y_k \leq \varepsilon + e_k^*, for\ k = 1,2, \dots., N, and \\ e_k, e_k^* \geq 0 \end{cases}$ $\qquad (2)$

Where the inequalities

$$w^t \varphi(x_i) \leq w^t \varphi(x_j), \text{ for all } x_i \leq x_j, \qquad (3)$$

Are the monotonicity constraints.
The Lagrangian for this problem is

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$$\tilde{\mathcal{L}}(w,b;\alpha,\beta) = J(w,e) - \sum_{k-1}^{N} \alpha_k \left([w^T \varphi(x_k) + b] - y_k + \varepsilon + e_k\right)$$

$$- \sum_{k=1}^{N} \alpha_k^* \left(y_k - [w^T \varphi(x_k) + b] + \varepsilon + e_k^*\right) \qquad (4)$$

$$- \sum_{i=1}^{M} \beta_i \left(w^T \varphi(\tilde{x}_i) - w^T \varphi(x_i)\right) - \sum_{k=1}^{N} (v_k e_k - v_k^* e_k^*),$$

with Lagrangian multipliers $\alpha_k, \alpha_k^*, v_k, v_k^* \geq 0$ for $k = 1, \dots, N$ and $\beta_i \geq 0$ for all $i = 1, \dots, M$. the optimal solution can be found at the saddle point of the Lagrangian by first minimizing over the primal variables w and b, and then maximizing over the dual multipliers $\alpha_k, \alpha_k^* \geq 0$ and $\beta_i \geq 0$

$$\max_{\alpha,\beta} \min_{w,b} \tilde{\mathcal{L}}(w, b, e; \alpha, \beta, v) \qquad (5)$$

Note that here by α and v, we refer to (α_k, α_k^*) and (v_k, v_k^*).

Taking the derivatives on wand b, one obtains a quadratic programming problem (dual problem) which has the following form.

$$\max_{\alpha,\beta} \tilde{Q}(\alpha,\beta) = -\frac{1}{2}\sum_{k=1}^{N}\sum_{l=1}^{N}(\alpha_k - \alpha_k^*)(\alpha_1 - \alpha_1^*)\varphi(x_k)^T\varphi(x_1)$$

$$-\frac{1}{2}\sum_{i=1}^{M}\sum_{j=1}^{M}\beta_i\beta_j(\varphi\tilde{x}_i)^T\left(\varphi(\tilde{x}_j) - \varphi(x_j)\right)$$

$$-\frac{1}{2}\sum_{k=1}^{N}\sum_{i=1}^{M}(\alpha_k - \alpha_k^*)\beta_i\left(\varphi(\tilde{x}_i) - \varphi(x_i)\right)^T\varphi(x_k)$$

$$-\frac{1}{2}\sum_{k=1}^{N}\sum_{i=1}^{M}(\alpha_k - \alpha_k^*)\beta_i\varphi(x_k)^T\left(\varphi(\tilde{x}_i) - \varphi(x_i)\right)$$

$$-\varepsilon\sum_{k=1}^{N}(\alpha_k + \alpha_k^*) + \sum_{k=1}^{N}y_k(\alpha_k - \alpha_k^*)$$

Subject   to

$$\sum_{k=1}^{N} (\alpha_k - \alpha_k^*) = 0,$$

$$0 \leq \alpha_k \leq C, \qquad k = 1, 2, \dots, N$$

$$0 \leq \alpha_k^* \leq C, \quad k = 1, 2, \dots, N$$

$$\beta_i \geq 0, i = 1, \dots, M$$

A kernel trick can be applied to this quadratic form. For any symmetric, continuous function $K: R^n \times R^n \to R$ satisfying Mercer's condition [45-47], there exists a mapping $\varphi(x)$ such that $K(x, x') = \varphi(x)^T \varphi(x')$ With an appropriate choice of kernel K, the nonlinear monotonicity constrained SVM regression takes the form:

$$y(\mathbf{x}) = \sum_{k=1}^{N} (\alpha_k - \alpha_k^*) K(\mathbf{x}_k, \mathbf{x}) + \sum_{i=1}^{M} \beta_i (K(\bar{\mathbf{x}}_i, \mathbf{x}) - K(\underline{\mathbf{x}}_i, \mathbf{x})) + b], \qquad (9)$$

Where $\alpha_k' s, \alpha_k^{*'} s$, and $\beta_i' s$ are the solution to the quadratic programming problem in (8). Now, we develop an algorithm to solve the proposed monotonicityconstrained support vector machine. Firstly, we write the objective function $\tilde{Q}(\alpha, \beta)$ in matrix form. For notational convenience, we re-index β and denote the new as $\bar{\beta}$ in the following manner. Suppose there are M elements in β. We can define a one-to-one mapping from the set $Ind_1 = \{s | s = 1, 2, \dots, M\}$ to the set $Ind_2 = \{(i,j) | x_i \leq x_j\}$ and denote it as $f(x)$. Now the optimization problem (5) can be rewritten as

$$\max_{\alpha, \bar{\beta}} \tilde{Q}(\alpha, \bar{\beta}) = -\frac{1}{2} [\alpha^T, \bar{\beta}^T] G \begin{bmatrix} \alpha \\ \bar{\beta} \end{bmatrix} + 1^T \alpha$$

subject to
$$\sum_{k=1}^{N} \alpha_k y_k = 0,$$

$$0 \leq \alpha_k \leq C, \quad k = 1, 2, \dots, N,$$

$$\bar{\beta}_s \geq 0, \quad s = 1, 2, \dots, M,$$

(7)

where G is a symmetric matrix.
Apparently, the above problem is a quadraticprogramming. If the matrix G is positive

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semidefinite, the solution is global. If G is positive definite the solution is global and unique. When G is indefinite there may exist localsolutions. Quadratic programming problems can be solved by any available quadratic programming solvers.

We applied the proposed method with Gaussian kernel. The hyperparameter C and the kernel parameters can be tuned by applying k-fold cross-validation on training/validation data to a grid search. The algorithm of monotonicity constrained SVR isplanned as follows.

Algorithm MC-SVR

Input: Observed dataset $\Im = \{(x_i, y_i)|i = 1,2, \ldots, N\}$

Output: $\propto, \beta$ and the corresponding classifier

Steps:

1. Determine the M pairs of monotonicity constraints $(x_i, \bar{x}_i)$ such that $x_i, \bar{x}_i$ for $i = 1, \ldots, M$

2. Compute the matrix G in (11).

3. Solve the quadratic programming problem in (12) for $\propto and \beta$ by a quadratic programming solver such as quadprog in MATLAB.

4. Apply k-fold cross-validation on training/validation data and repeat Step 3 to find the optimal parameters.

5. Output the optimal α and β

6. Determine the MC-SVR estimator as in (9).

EXPERIMENTAL RESULTS

We applied the proposed algorithm to approximate the sigmoid function

$$y(x) = \frac{1}{e^{-x} + 1},$$

on the interval [-1, 1]. In total, 100 even-spaced x values are used, along with their corresponding y values, to form the correct data set. Various perturbations, ranging from 5% to 25%, are applied to simulate artificial data.

Five-fold cross-validation was adopted in the experiment. Dataset was random divided into 5 approximately equal sets, and each set was used to test the classifier, and other sets were used to train the classifier. We repeated this step until all sets have been used to test the classifier once. The Table 1 shows the comparison on accuracy of original SVR and the proposed MC-SVR. The results of artificial datasets show that the proposed monotoncity constrained SVR performs better.

Table 1: Average SSE of MC-SVR and SVR on Sigmoid Data

Average SSE(Y=sigmoid(x))		Purturbation									
		0%	z-test	5%	z-test	10%	z-test	15%	z-test	20%	z-ttest
MCSVR	50	8.98E-07	1.141	2.53E-04	3.582	9.76E-04	1.970	1.29E-03	3.114	1.37E-03	3.011
	100	8.33E-07	1.207	2.12E-04	4.521	8.85E-04	2.495	1.31E-03	2.699	1.54E-03	1.881
	150	8.87E-07	0.948	2.25E-04	4.359	9.24E-04	2.279	1.25E-03	3.030	1.47E-03	2.991
	200	8.34E-07	1.202	2.15E-04	4.358	8.47E-04	2.581	1.28E-03	2.726	1.48E-03	2.340
	250	8.87E-07	0.926	2.24E-04	4.232	1.34E-03	-0.154	1.22E-03	3.049	1.40E-03	3.090
SVR		8.98E-07	\	4.33E-04	\	1.27E-03	\	1.94E-03	\	2.41E-03	\

* z(0.95)= 1.645

CONCLUSIONS

In many application areas of machine learning, there exists prior knowledge concerning the monotone relations between the response variable and predictor variables. For some cases, monotonicity is an important model requirement with a view toward explaining and justifying decisions. Therefore, in the study we propose a monotonicity constrained SVR that takes into account the monotone nature of problems. A quadratic programming problem in the dual space is developed similar to its SVR predecessor. We experimented the proposed method on the perturbed data made from Sigmoid function. The results showed that the proposed method has advantages over the original SVR.

REFERENCES

1. Burges, C. J. C. (1998). Data Mining Knowledge Discovery 2, 955-974.
2. Cristianini, N. & Shawe-Taylor, J. (2000). Cambridge University Press, 2000 - Ordering
   Information.
3. Daniels, H. & Kamp, B. (1999). Neural Computation and Applications 8, 226-234.
4. Doumpos, M. & Pasiouras, F. (2005). Computational Economics 25, 327-341.
5. Doumpos, M. & Zopounidis, C. (2009). new Mathematics and Natural Computation 5, 557 -570.
6. Duivesteijn, W. & Feelders, A. (2008). Nearest Neighbour Classification with Monotonicity
7. Constraints , , 2008 European Conference on Machine Learning and Knowledge Discovery in Databases, Antwerp, Belgium Springer-Verlag.
8. Evgeniou, T., C. & Boussios, e. a. (2005). Marketing Science 24, 415 - 429.
9. Falck, T., Suykens, J. & De Moor, B. (2009). *The 48th IEEE Conference on Decision and Control (CDC 2009)* Shanghai, China
10. Gamarnik, D. (1998). In: Proceedings of the eleventh annual conference on computational learning theory, ACM Press, New York. 134-143.

11. Greco, S., Matarazzo, B. & SꙇłowiĔski, R. (1998). In: Zopounidis, C. (ed.) Operational Tools in the Management of Financial Risks, Kluwer Academic Publishers, Dordrech. 121-136.
12. Huang, W., Nakamoria, Y. & Wang, S. Y. (2005). Computers & Operations Research 32, 2513-2522.
13. Kim, H. S. & Sohn, S. Y. (2010). European Journal of Operational Research 201, 838 - 846.
14. M□ller, K.-R., Smola, A., Rꙇ́tsch, G., Schꙉlkopf, B., Kohlmorgen, J. & Vapnik, V. (1997). *International Conference on Artificial Neural Networks* p. 999. Springer Lecture Notes in Computer Science.
15. Mukherjee, S., Osuna, E. & Girosi, F. (1997). *IEEE Workshop on Neural networks for Signal Processing 7*, pp. 511 - 519. Amelia Island, FL
16. Pazzani, M. J., Mani, S. & Shankle, W. R. (2001). Methods of Information in Medicine 40, 380-385.
17. Pendharkar, P. C. & Rodger, J. A. (2003). Decision Support Systems 36, 117-136.
18. Potharst, R. & Feelders, A. J. (2002). ACM SIGKDD Explorations Newsletter 4, 1-10.
19. Ryu, Y. U., Chandrasekaran, R. & Jacob, V. (2007). European Journal of Operational Research 181, 842-854.
20. Vapnik, V. N. (1995). *The Nature of Statistical Learning Theory*. New York: Springer-Verlag.
21. Vapnik, V. N. (1998). *Statistical Learning Theory*. New York:
22. Wiley. Wang, S. (2003). Computers and Operations Research 30, 17.

DESIGNN OF AN INTELLIGENT CONDITION-BASED KEY MACHINERY ASSETS MAINTENANCE MANAGEMENT PROTOTYPE SYSTEM

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ABSTRACT

Purpose: This paper presents the design and development of an intelligent condition-based key machinery assets maintenance management system for the textile industry using artificial intelligence (AI) and smart sensor techniques. Effective machinery assets maintenance management is very important for textile enterprises because it improves product quality and production output, optimizes manufacturing schedule, and reduces the probability of a sudden asset breakdown.

Design: An intelligent condition-based key machinery assets maintenance

Methodology: management (ICKAMM) system is proposed to obtain data, such as

Approach : real-time asset condition status from different types of sensor devices (e.g., infrared temperature, accelerometer, and optical sensors), and to monitor the current and/or predict the future states of an asset and thus provide recommendations for maintenance actions and operational decisions. The system uses AI techniques in managing, filtering, and analyzing the captured data to detect anomalies and predict future states of an asset for recommending maintenance actions and operational decisions.

Findings : The system prototype is being developed and evaluated in a real-world setting to enable companies to take remedial measures for optimizing manufacturing and maintenance schedules, detect anomalies, report potential problems, recommend maintenance and operational procedures, provide accurate assets condition status reports, and ultimately improve total business performance. The use of sensor devices in severe working conditions of production would be a real and practical challenge in condition-based assets maintenance management.

Originality: The proposed system framework for machinery health monitoring

Values : provides a flexible environment to integrate different types of sensor devices for the

real-time monitoring of the key components of the machinery of a production system. It also facilitates the development of customized maintenance management applications for the needs of different production systems.

Keywords: assets maintenance management; condition-based maintenance; smart sensor; artificial intelligence

Category: Research paper

INTRODUCTION

The increased internationalization of services led by the information and communication technology (ICT) revolution has reshaped the competitive landscape of production (Dahlman, 2007). The shorter product life cycle and the disintegration of the production process demand for integrated supply chains supported by suppliers that are capable of maintaining production quality and timely delivery. The reliability and the availability of production systems have become the determining factors for manufacturing suppliers to compete with time and to succeed.

Maintenance has been widely used as a strategic tool for reducing the downtime and the quality defects of production systems to improve productivity and product quality. Traditional maintenance approaches, including the purely reactive repairing or replacing machinery after failure and the blindly proactive performing routine maintenance regardless of conditions, are extremely wasteful and harmful to the competitiveness of manufacturing organizations (Lee et al., 2006). In fact, the degradation and failure of machinery asset in most cases are traceable or even predictable by monitoring the machinery conditions. Maintenance technology enables the gathering of real-time information of each asset in a production system for making condition-based maintenance (CBM) decisions. CBM combines the advantages of traditional maintenance strategies and supports both proactive maintenance to detect and correct failing root causes and predictive maintenance to monitor symptomatic conditions for predicting failure when correction is not possible (Starr et al., 2010). Advances in smart sensor technology enables the setting up of a low-cost wireless sensor network in small machinery spaces and difficult-to-access locations to continuously monitor the condition of the components of machinery asset in the production system to implement the CBM strategy (Tiwari, Balla and Lewis, 2007).

E-maintenance is an emerging concept that utilizes ICT technologies, maintenance technologies, and scientific approaches, particularly CBM, to achieve and sustain near-zero downtime performance in production. Different frameworks of e-maintenance systems have been proposed in the literature (e.g., Han and Yan, 2006; Iung et al., 2009; Voisin et al., 2010). However, because of the absence of a unified understanding, e-maintenance is perceived as directly linked to the development in e-technologies for improving maintenance efficiency,

velocity, and workflow, and for integrating and collaborating maintenance services with other e-enterprise services to enhance business performance (Levrat, Iung and Marquez, 2008; Muller, Marquez, and Iunga, 2008).

Recent studies suggest that e-maintenance systems with CBM enable manufacturing operations and automated systems to achive near-zero downtime performance and reduce maintenance cost (Han and Yang, 2006; Gilabert and Arnaiz, 2006; Niu and Yang, 2010). Integrating intelligence agents and machine learning techniques into e-maintenance systems can extend the adaptability of the systems and automate the maintenance management process across the manufacturing organization (Yu, Iung, and Panetto, 2003; McArthur, Strachan, and Jahn, 2004; Gilabert and Arnaiz, 2006). Mobile devices present great potential in providing a flexible environment for maintenance engineers to connect to smart detectors and for e-maintenance systems to obtain the relevant conditions and information about machinery assets for performing maintenance tasks (Arnaiz et al., 2006; Campos, Jantunen and Prakash, 2009; Irigaray et al., 2009; Arnaiz et al., 2010).

However, most of the research on CBM focuses on the technical aspects without paying much attention to industrial practices. An empirical study on five-process industry firms found that some of the common assumptions adopted in the design of CBM systems might not be fully supported in practice (Klingenberg and Wortmann, 2011).

Textile manufacturing is a very complex process that includes spinning, knitting, dyeing, printing, and finishing machines and production variations. A machine breakdown in one process usually requires the re-run of a production batch. Therefore, effective machinery assets maintenance management is important for textile enterprises because it improves product quality and production output, optimizes manufacturing schedule, and reduces the probability of a sudden asset breakdown. Implementing CBM in textile manufacturing needs a flexible framework that can easily integrate different types of sensor devices for the real-time monitoring of key machinery asset components in each process, building customized assets maintenance management applications, and integrating into enterprise systems to provide knowledge for making management decisions.

In this paper, we propose an intelligence condition-based key machinery assets maintenance management (ICKAMM) system for textile manfacturing. We first present the framework and implementation of the ICKAMM system and then report the progress and challenge faced in the pilot study of the prototype system.

FRAMEWOR OF THE PROPOSED INTELLIGENCE CONDITION-BASED KEY MACHINERY ASSET MAINTENANCE MANAGEMENT

Figure 1 illustrates the framework of the proposed ICKAMM system, which consists of three main tiers: (i) the asset condition acquisition (ACA) system, which captures asset condition

data collected by smart sensor technology; (ii) the core system, which includes a smart sensor network (SSN) for asset condition data acquisition system connection and intelligent asset condition management executive system; and (iii) the intelligent asset condition-based maintenance management system for the textile asset management and manufacturing process.

Figure 1: Framework of the ICKAMM System

The ICKAMM system utilizes AI, smart sensor technology, as well as industrial control technologies and methodologies to build up a complete system for facilitating the automated capture of real-time asset condition status from different types of sensor devices in the textile manufacturing sectors. Apart from these data capturing and manipulating systems, the proposed system framework consists of three parts:

1. Asset condition acquisition (ACA) system – the ACA system uses the smart sensor technology and communication technologies, such as Wi-Fi, Bluetooth and ZigBee, to obtain the required data. It can integrate with different types of sensors to monitor the key asset condition information in the textile manufacturing industry.

2. Core System (Asset Condition Management Executive System) – the core system includes seven modules that can be divided into three layers: (i) data capturing module that connects with the ACA via the SSN; (ii) modules, including production data module, knowledge-based management module, data alerting module, asset data maintenance module, track and trace module, that process the data streamed from the data capturing

module for the next layer and export to the external enterprise systems such as ERP; and (iii) intelligent asset condition engine (IACE). The functions of the modules are as follows:

- Data Capturing Module – this module responsible to acquire data of key assets from the SSN.
- Production Data Module - this module provides the on-going production process information, such as the type and quality of fabric.
- Data Alerting Module - this module provides real-time data monitoring features, such as the detection of abnormal asset condition. When the module detects any mistakes or errors, it will automatically alert the system for further action.
- Asset Data Maintenance Module - this module can translate real-time sensor data captured by the smart sensor embedded device into various asset condition records based on the pre-defined model rule. If the module detects any non-defined data, it will alert the system for further action.
- Knowledge-Base Management Module - this module provides the pre-defined asset condition identification model base of different types of asset condition data mentioned above; the knowledge base management module including below three sub-modules:
  - Rule-based sub-module detects and identifies equipment faults in accordance with the rules representing the relation of each possible fault with the corresponding condition.
  - A model-based sub-module uses various mathematical models and neural network to improve diagnostic reasoning based upon the structure and properties of the equipment system. A model-based sub-module compares the real monitored condition with the model of the object in order to predict the fault behaviour.
  - Case-based sub-module use historical records of maintenance cases to provide an interpretation for the actual monitored conditions of the equipment.
    More Knowledge Base Management sub modules can be developed to extend the system performance in the future.
- Tracking and Monitoring Module - this module can track and monitor different items by obtaining real-time object status in the manufacturing processes.
- Intelligent Asset Condition Engine (IACE) - the engine is based on the both online and offline asset status data, different knowledge base algorithms and manufacturing logics from "processing unit" to support the asset condition monitoring, health diagnostic and prognostic analysis. The intelligent engine will employ AI techniques to manage, filter, and analyze the captured data from the system in order to optimize manufacturing and maintenance schedule, detect anomalies, isolate faults, predict potential problems, and recommend actions to maintenance personnel and operators. It provides the supporting function for developing management application in the next application tier.

3.   Applications (Asset Maintenance Management Application System) – this is major applications of the ICKAMM system, which includes different modules of asset maintenance, e-Document, real-time asset monitoring and other customized applications for the textile asset management and manufacturing process.

IMPLEMENTATION OF THE ICKAMM PROTOTYPE SYSTEM

The asset condition data acquisition system prototype has been designed and developed to support the textile manufacturing process. Figure 2 depicts different type of asset condition capturing sensor technology used in a key machinery asset component.

Figure 2: Smart Sensors Used in a Key Asset Component

There are different data capturing front-end systems used to obtain necessary information from the smart sensor technology embedded device, which is incorporated into different types of textile production assets. The prototype includes three devices:

- Smart agent with sensor- it can collect an asset condition status data based on one or many different types of smart sensor devices (e.g., pressure, temperature, and speed).
- Smart panel devices- these can capture the fabric and machine ID by automatic devices, such as barcodes, and enter process information, such as quantity and weight; then, it sends data to the smart sensor router through an SSN when starting, pausing, or completing each manufacturing process.
- Smart sensor router- this is installed around the manufacturing plant to forward the data

to the intelligent asset condition management executive system, which in turn, receives and processes the incoming data.

Figure 3 illustrates the overview of a real-time asset condition data acquisition system and shows how the asset condition data can be captured by smart sensor technologies.

Figure 3: Real-time Asset Condition Data Acquisition System

The smart agent will collect an asset condition status from different sensors and then monitor the asset condition status, such as operational temperature which indicates the motor's state. If the motor temperature increases suddenly or gradually to an unstable level as indicated in the trend analysis diagram, future problems with the motor are predicted to occur. The proposed system can detect this anomalous "trend" and identify the asset condition status to prevent fatal breakdown of assets. Figure 4 shows how the proposed system can predict the asset condition status using the "trend analysis" technique.

Figure 4: Trend Analysis

With this emerging new technology, the integrated sensor would be able to detect and transmit the real-time asset condition data with a batch or production order (PO) number, which is captured by a smart panel device, such as Barcode or RFID technologies. The data are then sent to the backend system for evaluation. The system could also help the user view the current asset status, predict asset condition status, and provide recommendations for maintenance actions and operational decisions.

PROGRESS AND CHALLENGE IN THE PILOT STUDY

Pilot study is being setup and implemented in test-bed located in Mainland China. The goal of the pilot study is to set up and develop the network using asset condition data acquisition system and different types of sensor devices.

Key assets in the dyeing, printing, and finishing in textile manufacturing processes were selected, including heat-setting machine, dyeing machine and mercerizing machine. Key components of the selected assets include motors and shafts. Sensor devices include infrared temperature, accelerometers, and optical sensors will be used to obtain condition data of those key components. At present, the installation of sensor devices for detecting motor condition status using vibration sensor technology has been completed. Testing and evaluation of using sensor devices for detecting leaking conditions and for monitoring machinery chains are still in progress because difficulties encountered in the use of sensor devices in severe working conditions of textile production. Due to the highly corrosive and acidic of dyeing process chemicals, the leaking sensor can be easily oxidized and fail to work properly. To successfully implement a condition-based assets maintenance management system, building a SSN under severe production environment would be a real and practical challenge. The durability and robustness of sensor devices would be a critical factor.

After the completion of the installation of sensor devices, the ICKAMM system will based on the captured and processed data to monitor the current, predict future states of an asset, and provide recommendations for maintenance actions and operational decisions to the management and maintenance engineers of the participation companies. It would enable companies to take remedial measures for optimizing manufacturing and maintenance schedules, detect anomalies, report potential problems, recommend maintenance and operational procedures, provide accurate assets condition status reports, and, ultimately, improve total business performance.

ACKNOWLEDGEMENTS

REFERENCES

1. Arnaiz, A., Iung, B., Adgar, A., Naks, T., Tohver, A., Tommingas, T. and Levrat, E.(2010), "Information and Communication Technologies Within E-maintenance." *E-maintenance*. Springer London, pp. 39-60.

2. Arnaiz, A., Emmanouilidis, C., Iung, B., and Jantunen, E. (2006), "Mobile maintenance management", *Journal of International Technology and Information Management*, Vol. 15 No. 4, pp. 11-21.

3. Campos, J., Jantunen, E., and Prakash, O. (2009), "A web and mobile device architecture for mobile e-maintenance", *The International Journal of Advanced Manufacturing Technology*, Vol. 45 No. 1-2, pp. 71-80.

4. Dahlman, C. (2013), "Technology, globalization, and international competitiveness: challenges for developing countries", *Industrial Development for the 21st Century: Sustainable Development Perspectives*, Department of Economic and Social Affairs, United Nations, New York.

5. Gilabert, E., and Arnaiz, A. (2006), "Intelligent automation systems for predictive maintenance: A case study", *Robotics and Computer-Integrated Manufacturing*, Vol. 22 No. 5, pp. 543-549.

6. Han, T., and Yang, B. S. (2006), "Development of an e-maintenance system integrating advanced techniques", *Computers in Industry*, Vol. 57 No. 6, pp. 569-580.

7. Irigaray, A. A., Gilabert, E., Jantunen, E., and Adgar, A. (2009), "Ubiquitous computing for dynamic condition-based maintenance", *Journal of Quality in Maintenance Engineering*, Vol. 15 No. 2, pp. 151-166.

8. Iung, B., Levrat, E., Marquez, A. C., and Erbe, H. (2009), "Conceptual framework for e-Maintenance: Illustration by e-Maintenance technologies and platforms", *Annual Reviews in Control*, Vol. 33 No. 2, pp. 220-229.

9. Lee, J., Ni, J., Djurdjanovic, D., Qiu, H., and Liao, H. (2006), "Intelligent prognostics tools and e-maintenance", *Computers in industry*, Vol. 57 No. 6, pp. 476-489.

10. Levrat, E., Iung, B., and Crespo Marquez, A. (2008), "E-maintenance: review and conceptual framework", *Production Planning and Control*, Vol. 19 No. 4, pp. 408-429.

11. McArthur, S. D., Strachan, S. M., and Jahn, G. (2004), "The design of a multi-agent transformer condition monitoring system", *Power Systems, IEEE Transactions on*, Vol. 19 No. 4, pp. 1845-1852.

12. Muller, A., Crespo Marquez, A., and Iung, B. (2008), "On the concept of e-maintenance: Review and current research", *Reliability Engineering & System Safety*, Vol. 93 No. 8, pp. 1165-1187.

13. Niu, G., and Yang, B. S. (2010), "Intelligent condition monitoring and prognostics system based on data-fusion strategy", *Expert Systems with Applications*, Vol. 37 No. 12, pp. 8831-8840.

14. Starr, A., Al-Najjar, B., Holmberg, K., Jantunen, E., Bellew, J. and Albarbar, A. (2010), "Maintenance Today and Future Trends", *E-Maintenance*, Springer London, pp. 5-37.

15. Tiwari, A., Ballal, P., and Lewis, F. L. (2007), "Energy-efficient wireless sensor network design and implementation for condition-based maintenance", *ACM Transactions on Sensor Networks (TOSN)*, Vol. 3 No. 1, pp. 1-23.
16. Veldman, J., Klingenberg, W., and Wortmann, H. (2011). "Managing condition-based maintenance technology: a multiple case study in the process industry", *Journal of Quality in Maintenance Engineering*, Vol. 17 No. 1, pp. 40-62.
17. Voisin, A., Levrat, E., Cocheteux, P., and Iung, B. (2010), "Generic prognosis model for proactive maintenance decision support: application to pre-industrial e-maintenance test bed", *Journal of Intelligent Manufacturing*, Vol. 21 No. 2, pp. 177-193.
18. Yu, R., Iung, B., and Panetto, H. (2003), "A multi-agents based E-maintenance system with case-based reasoning decision support", *Engineering applications of artificial intelligence*, Vol. 16 No. 4, pp. 321-333.

BIOSKETCH

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DEVELOPMENT OF OPERATION TRACKING BY USING INTERNAL BENCH MARKING

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ABSTRACT

An internal benchmarking concept was introduced as alternative method to assess production process performance (Hopp and Spearman, 2008). A popular benchmarking approach inquiries information related to interest performance indicators from external organization/department. The main obstacles of applying typical benchmarking approach are a collaboration from the external organization and a reliability of received performance indicators. In contrast, internal benchmarking compares the actual production process performance with management theory. The internal benchmarking approach develop two area of production process performance: 1) good region and 2) bad region. Based on three basic production performance measures, production rate, time-in-system and level of work-in-process, overall performance of production line can be categorized into either good region or bad region. When the production line performance falls into bad region, it means that the production line must be improved immediately. However, the concept of internal benchmarking by Hopp and Spearman does not mentioned about multi-product production line.

As a result, this research intend to extend the concept of internal benchmarking for multi-product type of production line and uses an extended internal benchmarking model as process monitoring indicator in order to prevent the overall performance of production line falls into a bad region. Two main factors are added into the current original model: 1) Multi-product production line 2) Independent failed events such as breakdown or yield drop of individual workstation. According to the experimental data, by tracking individual product performance (WIP, throughput rate and cycle time) of the multi-product production line, undesirable event which lead to performance deterioration can be detected faster than monitoring individual workstation. In particular when the undesirable event occurs at the low demand product (less machine time). In addition, this research has confirmed that the concept of internal

benchmarking can be adopted as process monitoring indicator. Future integration with trend analysis can be included to speed up detection time.

INTRODUCTION

Today, manufacturing operation is under highly competitive environment for both cost, quality and time of service. In order to maintain competitiveness, management of any production facility need to identify source of problems and mitigate them in timely manner. An internal benchmarking concept was introduced as alternative method to production process performance (Hopp and Spearman, 2008). A popular benchmarking approach inquiries information related to interest performance indicators from external organization/department. The main obstacles of applying typical benchmarking approach are a collaboration from the external organization and a reliability of received performance indicators. In contrast, internal benchmarking compares the actual production process performance with management theory. The internal benchmarking approach develop two area of production process performance: 1) good region and 2) bad region. Based on three basic production performance measures, production rate, time-in-system and level of work-in-process, overall performance of production line can be categorized into either good region or bad region. When the production line performance falls into bad region, it means that the production line must be improved immediately. However, the concept of internal benchmarking by Hopp and Spearman does not mentioned about multi-product production line. Therefore, this research intend to extend the concept of internal benchmarking for multi-product type of production line and uses an extended internal benchmarking model as process monitoring indicator in order to prevent the overall performance of production line falls into a bad region. The main objectives of this research are:

1) Diagnose the production line by using internal benchmarking methodology that refers to Hopp and Spearman (2008).
2) Detecting and monitoring production performance by daily
3) Multiple product can be monitored and tracked by data base

BACKGROUND

Little's law (Little, 1961) can be applied to describe the relationship between WIP and cycle time. Since these relationships were derived for perfect lines with no variability, the following expressions indicate the maximum throughput and minimum cycle time for a given WIP level for any system having parameters such as Bottleneck rate (r_b) and the sum of the long-term average process times of each workstation in the line (T_0). To be brief, based on relationships in Little's law, three performance situations can be defined below:

Best-Case Performance

The best-case line with WIP equal to the critical WIP because there is no waiting (queuing) in a line that this achieve the minimum possible cycle time.

$$CT_{best} = \begin{cases} T_0 & \text{If } w \leq W_0 \\ \\ \dfrac{w}{r_b} & \text{Otherwise} \end{cases} \quad (1)$$

$$TH_{best} = \begin{cases} \dfrac{w}{T_0} & \text{If } w \leq W_0 \\ \\ r_b & \text{Otherwise} \end{cases} \quad (2)$$

Worst-Case Performance

The worst case situation reflects a scenario when the maximum cycle time and minimum throughput possible for a line with bottleneck rate and raw process time. This will help to bracket the behavior and measure the performance of the real line. If a line is closer to the worst case than to the best case, them there are some real problems.

The maximum cycle time for a given WIP level w is given by

$$CT_{worst} = wT_0 \quad (3)$$

The minimum throughput for a given WIP level w is given by

$$TH_{worst} = \dfrac{1}{T_0} \quad (4)$$

Practical Worst-Case Performance

Practical worst case considers an intermediate case, which behaves between the best case and the worst case. This case involves randomness and unlike the previous two cases. In fact, in a sense, it represents the "maximum randomness" case. The worse behavior is a target for improvement.

The practical worst case can be regarded as the maximum randomness case causes every possible to occur with equal frequency. When randomness is introduces into a line, more states become possible. If there is only a little randomness, then the frequency of the spread-out state will be very high, whereas if there is a lot of randomness, then all the states may occur quite often. Hence, we define the maximum randomness scenario to be practical worst case.

The practical worst-case (PWC) cycle time for a given WIP level *w* is given by

$$CT_{pwc} = T_0 + \frac{w-1}{r_b} \qquad (5)$$

The PWC throughput for a given WIP level *w* is given by

$$TH_{pwc} = \frac{w}{(W_0 + w - 1)} x\, r_b \qquad (6)$$

Notice that the behavior of this case is reasonable for both extremely low and extremely high WIP levels. At one extreme, when there is only one job in the system (w=1), cycle time becomes raw process time T_o. At the other extreme, as the WIP level is more than 1 (that is W→∞), throughput approaches capacity r_b, while cycle time increase without bound. Whenever, achieving throughput close to capacity in systems with high variability requires high WIP levels, in order to ensure high utilization of machines. But this also ensures a great deal of waiting and hence high cycle times. The throughput and cycle time of practical worst case are always between those of the best case and worst case. As such, the PWC provides a useful midpoint that approximates the behavior of many real systems. By collecting data on average WIP, throughput, and cycle time for a real production line, we can determine whether it lies in the region between the best case (green line) and practical worst case(blue line); best region, or between worst case (red line) and practical worst case; bad region, those like in Figure 1 and Figure 2. Better performance that the PWC are good and worse performance are bad. It makes sense to focus our improvement efforts on the bad lines because they are the ones with room for improvement. This is a concept of using WIP, TH and CT to benchmark production performance. For this research, we do further in using this three measures for performance tracking purpose.

METHOD & EXPERIMENTS

For multiple products (A, B and C) can bring actual data to model by equation as below. The equation is based on divided by product ratio; the actual internal benchmarking concept for a given WIP level w is given by

Best case performance

$$CT_{best} = T_o = \%A * T_A + \%B * T_B + \%C * T_C \qquad (7)$$

$$TH_{best} = r_b = \%A * r_{b(a)} + \%B * r_{b(B)} + \%C * r_{b(C)} \qquad (8)$$

Worst case performance

$$CT_{wc} = W.T_0 = (W_A + W_B + W_C) * T_0 \qquad (9)$$

$$TH_{WC} = \frac{1}{\%A * T_A + \%B * T_B + \%C * T_C} \qquad (10)$$

Practical worst case performance

$$CT_{PWC} = T_O + (\frac{W-1}{r_b}) = T_0 + \frac{(W_A + W_B + W_C - 1)}{r_b} \qquad (11)$$

$$TH_{PWC} = T_O + (\frac{W}{W_0 + W - 1}) * r_b = (\frac{(W_A + W_B + W_C)}{W_0 + (W_A + W_B + W_C) - 1}) * r_b \qquad (12)$$

Experiments

The experiment setting are shown in Table 1. To assume data yield drop or down time of machine operation by set date to start yield drop then check and compare the result from graph with indicator can detect and track as fast speed as occurring the problem. The result of testing will be represented obviously on conclusion and discussion topic by graph and data table for comparing visualization. They were designed to answer the following questions.

Research Question 1: Can it detect trend?

Research Question 2: Can it identify problem area?

Research Question 3: Can it track individual product?

There are 2 main responses for all experiments

1) Response time to original (% Yield drop detection).
   Assume percentage yield drop data into model and compare individual graph (divided by product, machine, and line performance) which indicator are detection fast speed in each experiment.

2) Impact of product ratio (% percentage ratio)

Percentage of product in each product affects to monitor and track the problem to detect.

Table 1: Experimental Data

Machine	Process	Ratio (%)	CT/ MC (sec)	Second / piece
		Machine 1		
MC 1	Part A	60.0%	148.00	88.8
	Part B	30.0%	150.00	45.0
	Part C	10.0%	144.00	14.4
	Average		147.33	148.2
		Machine 2		
MC 2	Part A	60.0%	160.00	96.0
	Part B	30.0%	170.00	51.0
	Part C	10.0%	165.00	16.5
	Average		165.00	163.5
		Machine 3		
MC 3	Part A	60.0%	220.00	132.0
	Part B	30.0%	212.00	63.6
	Part C	10.0%	230.00	23.0
	Average		220.67	218.6

RESULTS AND CONCLUSION

Internal Benchmarking methodology can bring to factory and detect problem In multiple product and line process that was divided for detect the problem which product or machine is indicator, that problem should be improved line process Immediately for protection uncontrolled factor occur.

Table 2 Comparison monitoring results

Comparison failure detection performance	TH (Found)	CT (Found)	% Found	
Product > Machine	45	45	62.5%	*68.75%
Product > Original data	54	54	75%	
Machine > Original data	46	46	63.8	49.95%
Machine > Product	26	26	36.1	
Original > Machine	25	25	34.7	29.85%
Original > Product	18	18	25	

As data shown in table 2, to compare methods to detect trend of failure found, the result is shown both thought put rate and cycle time by percentage.

Table 3 Tracking and monitoring date table

Day	5-10	10-15	15-20	21-25	25-31
Throughput and Cycle time	3	46	16	7	0

Note: Number in table is many days that Actual line and Practical worst case line overlap

As data shown in table 3, to summary tracking date in period times which period time can be found failure performance and the conclusion which type of speed up detection is respectively following as:

1) Product line performance can be fastest detect than machine line   Performance line and line process performance by time measure detection by ranking score
   - Product line performance
   - Machine line performance
   - Line process performance respectively

2) Line process that has occurred the percentage yield drop and loss time while on process; model can detect trend line down as bench marking concept.

3) Percentage of product ratio is once factors to line performance directly

The result as above can explain; product line performance can detect in best detection and observation by product line as result is 72 experiments.

REFERENCES

1. Bradley, M. G. (2002). A Taxonomy of The Adoption of Lean Production Tools and Techniques. Ph.D. Dissertation, University of Tennessee.

2. Buzacott, J.A. and J. G. (1993). Stochastic Models of Manufacturing Systems. Prentice-Hall, United Stated of America.

3. Hopp, W., and M. Spearman (2000). Factory Physics: Foundations of Manufacturing Management, 2nded. New york.

4. Little, J. D. C. 1961. A Proof of the Queuing Formula: L =λW. Operations Research 9(3): 383-387.

5. Suri, R., J.L. Sanders and M.Kamanth 1993. Performance Evaluation of Production Networks in Handbook in Operation Research and Management Science, Vol4, North – Holland.

DEVELOPMENT OF DECISION SUPPORT SYSTEM FOR PRODUCTION PLANNING FOR SME IN PHARMACEUTICAL INDUSTRY

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ABSTRACT

Recently, there are a rapid growth in pharmaceutical industry due to the increase awareness in health issues. The stock keeping unit (SKU) has increased in particular in supplementary medicine like vitamin. As a result, production planning in pharmaceutical has to deal with variety of products, shorter lead time and smaller lot size. In general, process of pharmaceutical industry is a flow shop where major processes are measuring, mixing or blending and packaging. In order to handle product variety and rush/priority order (shorter lead time), production planner needs a decision support system to assist him/her in certain scenarios of alternatives in planning. This research proposed a prototype of a decision support system in evaluating planning alternatives where they have identified in three main scenarios 1) Estimation of Completion time without changing current production schedule 2) switching order priority (or sequencing) 3) increasing resources such as overtime or extra worker. In addition to decision support system, the process monitoring has been found to be vital to production planner to adjust the current production plan to align with the recent issues in production floor. In the case study where the prototype of decision support system has been tested, process monitoring helps increasing awareness in production status to planner so he/she can quickly modify production plan or adjust priority before problems start to accumulate that often force planner to choose a costly way to response to the problems

Keywords: Decision Support System, Resource planning, flow shop scheduling

INTRODUCTION

Recently, there are a rapid growth in pharmaceutical industry due to the increase awareness in health issues. The stock keeping unit (SKU) has increased in particular in supplementary medicine like vitamin. As a result, production planning in pharmaceutical has to deal with variety of products, shorter lead time and smaller lot size. In general, process of pharmaceutical industry is a flow shop where major processes are measuring, mixing or blending and packaging. In order to handle product variety and rush/priority order (shorter lead time), production planner needs a decision support system to assist him/her in certain scenarios of alternatives in planning. Flow shop scheduling problems, are a class of scheduling problems with a group of machines or processes in which the flow control logic give an appropriate sequencing for each job and for processing on a set of machines or with other resources 1,2,...,m in compliance with given processing orders. Especially the maintaining of a continuous flow of processing tasks is desired with a minimum of idle time and a minimum of waiting time. However, in practice, scheduling logic is not automated but often perform by production planner who simply using simple rule such as FCFS (first come first serve), EDD (Earlier due date) or priority of orders etc. with current production conditions. Therefore, production planner need a tool that provide information about shop floor status for a given planning period (in advance) with certain schedule. The tool must be able to adjust sequence based on certain attribute like processing time or due date or manually modify by planner himself/herself. This research proposed a prototype of a decision support system in evaluating planning alternatives where they have identified in three main scenarios 1) Estimation of Completion time without changing current production schedule 2) switching order priority (or sequencing) 3) increasing resources such as overtime or extra worker. In addition to decision support system, the process monitoring has been found to be vital to production planner to adjust the current production plan to align with the recent issues in production floor. In the case study where the prototype of decision support system has been tested, process monitoring helps increasing awareness in production status to planner so he/she can quickly modify production plan or adjust priority before problems start to accumulate that often force planner to choose a costly way to response to the problems

LITERARURE REVIEW

Master Production Scheduling

According to Vollmann et al. (2005), the master production schedule (MPS) translates the sales and operations plan of the company into a plan for producing specific products in the future. Where the sales and operations plan provides an aggregate statement of the manufacturing output required to reach company objectives, the MPS is a statement of the

specific products that make up that output. The MPS is the translation of the sales and operations plan into producible products with their quantities and timing determined.

On a day-to-day basis, the MPS provides the information by which sales and manufacturing are coordinated. The MPS shows when products will be available in the future, thereby providing the basis for sales to promise delivery to customer. These promises will be valid as long as manufacturing executes the MPS according to plan. When conditions arise that create customer promise dates that are unacceptable from a marketing or manufacturing perspective, the MPS provides the basis for making the required trade-offs. At the operational level, the most basic concern is with the construction of the MPS record and updating it over time. The MPS record is developed to be compatible with the material requirements planning (MRP) system and to provide the information for coordinating with sales. Over time, as production is completed and products are used to meet customer requirements, the MPS record must be kept up to date. Doing this means implementing a periodic review and update cycle that we term "rolling through time". Updating the record involves processing MPS transactions, maintain the MPS record, responding to exception conditions, and measuring MPS effectiveness on a routine basis. Performing these tasks effectively will keep manufacturing resources and output aligned with the sales and operations plan. Figure 1 presents a partial schematic for the overall manufacturing planning and control system showing the linkages to master production scheduling. The detailed schedule produced by the MPS drives all the engine and, subsequently, the back-end system, as well as the rough-cut capacity planning activities.

Figure 1 Master Production Scheduling in the Manufacturing planning and control (MPC) System
Source: Vollmann et al. (2005)

METHOD

In this research, decision support system based on Microsoft Excel was developed as prototype for concept testing. At this stage, three production planner scenarios are set as a target for the development of decision support tool for production planner.

Schedule Compression

This scenario is considered very useful for production planner when there is a request for rush order which the size of order consider small or medium. The logic for providing the schedule adjustment is that the schedule can be compressed without causing significant change at the whole schedule by reorganizing bottleneck station. First, searching a gap or idle time slot at the bottleneck station for a given planning period. Then relocate an order which required less than 5 hours to be completed for that slot. If overtime is required to complete that order, overtime must be granted. The decision support will identify the order that fit the criteria above and present it to production planner to choose until a rush order can be fit in the schedule as request.

Figure 2. Information presented to planner for small size order (less than 5 hrs) by DSS

Reloading order

Further, similar concept to schedule compression, the decision support tool provides information regarding waiting time at each machine in the process or workstation. In this case, waiting time at each machine represents loading status at each machine. If the machine loading at particular process or workstation is well balanced, the value of waiting time at each machine should be close among all machines. If there are significant difference in waiting time at each machine, new order should be located at eligible machine which has the smallest waiting time. In addition, planner can also consider to move order from the highest waiting time machine to lower waiting time station before adding a new order if a new order must be loaded at the highest waiting time machine.

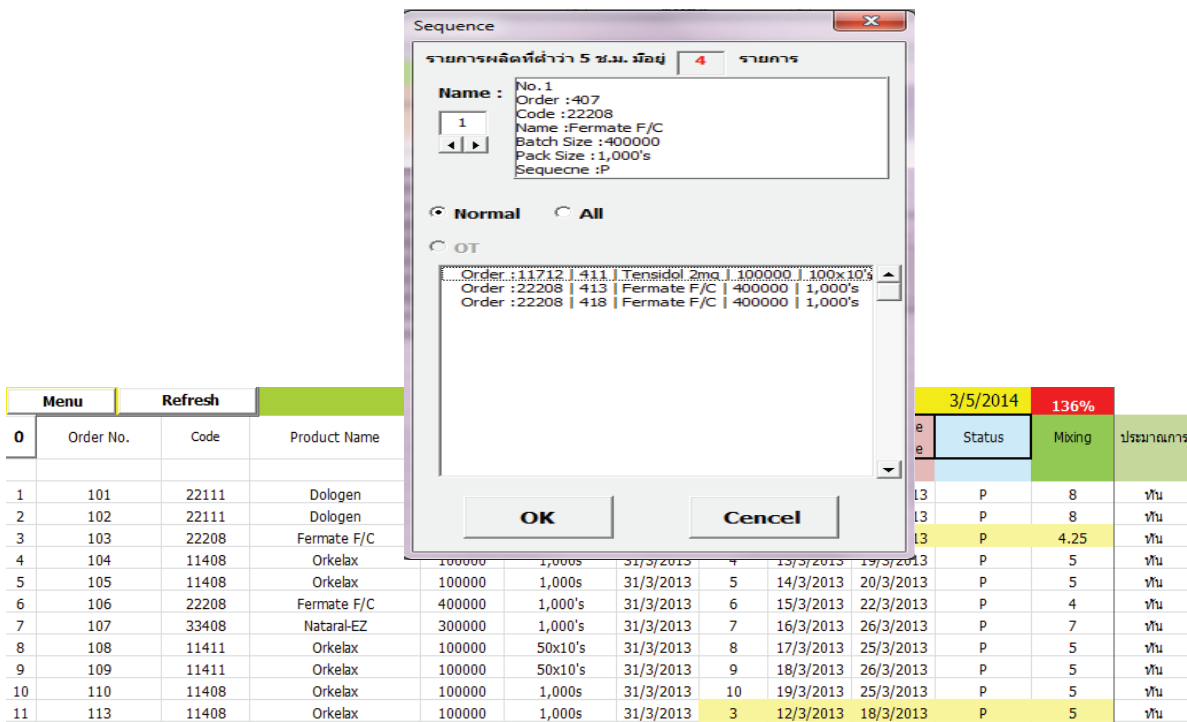| Percent- Machine								284%							
Product Name	Batch size	Pack size	Due date	Start Date	End Date	Compessing					Total time				
						Arrive(hr.)	Wait(hr.)	Start(hr.)	Time(hr.)	Finish (hr.)	day	time(hr.)	Over time(hr.)	Late(hr.)	เครื่องที่
Dologen	200000	50x10's	31/3/2013	4/3/2013	5/3/2013	17	0	17	12	29	1	3	0	0	1
Dologen	200000	50x10's	31/3/2013	5/3/2013	6/3/2013	25	4	29	12	41	1	3	0	0	1
Fermate F/C	400000	1,000's	31/3/2013	6/3/2013	7/3/2013	29.25	0	29.25	16	45.25	1	7	0	0	2
Orkelax	100000	1,000s	31/3/2013	7/3/2013	10/3/2013	34.25	0	34.25	12	46.25	1	3	0	0	3
Orkelax	100000	1,000s	31/3/2013	8/3/2013	11/3/2013	39.25	7	46.25	12	58.25	1	3	0	0	3
Fermate F/C	400000	1,000's	31/3/2013	9/3/2013	10/3/2013	43.5	2	45.25	16	61.25	1	7	0	0	2
Nataral-EZ	300000	1,000's	31/3/2013	11/3/2013	12/3/2013	59.5	2	61.25	12	73.25	1	3	0	0	2
Percent- Machine								284%							
Product Name	Batch size	Pack size	Due date	Start Date	End Date	Compessing					Total time				
						Arrive(hr.)	Wait(hr.)	Start(hr.)	Time(hr.)	Finish (hr.)	day	time(hr.)	Over time(hr.)	Late(hr.)	เครื่องที่
Dologen	200000	50x10's	31/3/2013	4/3/2013	5/3/2013	17	0	17	12	29	1	3	0	0	1
Dologen	200000	50x10's	31/3/2013	5/3/2013	6/3/2013	25	4	29	12	41	1	3	0	0	1
Fermate F/C	400000	1,000's	31/3/2013	6/3/2013	7/3/2013	29.25	0	29.25	16	45.25	1	7	0	0	2
Orkelax	100000	1,000s	31/3/2013	7/3/2013	10/3/2013	34.25	0	34.25	12	46.25	1	3	0	0	3
Orkelax	100000	1,000s	31/3/2013	8/3/2013	11/3/2013	39.25	7	46.25	12	58.25	1	3	0	0	3
Fermate F/C	400000	1,000's	31/3/2013	9/3/2013	10/3/2013	43.5	2	45.25	16	61.25	1	7	0	0	2
Orkelax	100000	1,000s	15/3/2013	10/3/2013	13/3/2013	48.5	13	61.25	12	73.25	1	3	0	0	2
Nataral-EZ	300000	1,000's	31/3/2013	12/3/2013	13/3/2013	64.5	9	73.25	12	85.25	1	3	0	0	2
Orkelax	100000	50x10's	31/3/2013	12/3/2013	15/3/2013	60.5	-2	58.25	12	70.25	1	3	0	0	3
Orkelax	100000	50x10's	31/3/2013	13/3/2013	16/3/2013	65.5	5	70.25	12	82.25	1	3	0	0	3

Figure 3. Waiting time of each machine of the process by DSS (Before & After adjustment)

Adding overtime

When plan is very tight due date, it is very difficult to change a sequence without an impact to promised due date. Often, overtime is a common solution. The question that face planner is which order and where in the process to allow overtime at a particular date. The best overtime scenario should be the amount where the current completion date of the rush order exceeds the due date. The proposed excel based decision support system provide the impact to overall schedule of given overtime at particular date for a specific order. This will save time of production planner and allow planner to explore several alternatives (logics).

Percent- Machine								311%					
Product Name	Batch size	Pack size	Due date	Start Date	End Date	Compessing					Total time		
						Arrive(hr.)	Wait(hr.)	Start(hr.)	Time(hr.)	Finish (hr.)	day	time(hr.)	Over time(hr.)
Dologen	200000	50x10's	31/3/2013	4/3/2013	5/3/2013	17	0	17	12	29	1	3	0
Orkelax	100000	50x10's	15/3/2013	5/3/2013	6/3/2013	22	0	22	12	34	1	3	0
Dologen	200000	50x10's	31/3/2013	6/3/2013	7/3/2013	25	0	25	12	37	1	3	0
Fermate F/C	400000	1,000's	31/3/2013	7/3/2013	8/3/2013	29.25	0	29.25	16	45.25	1	7	0
Orkelax	100000	1,000s	31/3/2013	8/3/2013	11/3/2013	34.25	0	34.25	12	46.25	1	3	0
Orkelax	100000	1,000s	31/3/2013	9/3/2013	12/3/2013	39.25	7	46.25	12	58.25	1	3	0
Fermate F/C	400000	1,000's	31/3/2013	10/3/2013	11/3/2013	43.25	2	45.25	16	61.25	1	7	0
Nataral-EZ	300000	1,000's	31/3/2013	12/3/2013	13/3/2013	59.25	2	61.25	12	73.25	1	3	0
Orkelax	100000	50x10's	31/3/2013	12/3/2013	15/3/2013	55.25	3	58.25	12	70.25	1	3	0
Orkelax	100000	50x10's	31/3/2013	13/3/2013	16/3/2013	60.25	10	70.25	12	82.25	1	3	0
Percent- Machine								311%					
Product Name	Batch size	Pack size	Due date	Start Date	End Date	Compessing					Total time		
						Arrive(hr.)	Wait(hr.)	Start(hr.)	Time(hr.)	Finish (hr.)	day	time(hr.)	Over time(hr.)
Dologen	200000	50x10's	31/3/2013	4/3/2013	5/3/2013	17	0	17	12	29	1	3	0
Orkelax	100000	50x10's	15/3/2013	5/3/2013	5/3/2013	22	0	22	12	34	1	-1	4
Dologen	200000	50x10's	31/3/2013	6/3/2013	7/3/2013	25	0	25	12	37	1	3	0
Fermate F/C	400000	1,000's	31/3/2013	7/3/2013	8/3/2013	29.25	0	29.25	16	45.25	1	7	0
Orkelax	100000	1,000s	31/3/2013	8/3/2013	11/3/2013	34.25	0	34.25	12	46.25	1	3	0
Orkelax	100000	1,000s	31/3/2013	9/3/2013	12/3/2013	39.25	7	46.25	12	58.25	1	3	0
Fermate F/C	400000	1,000's	31/3/2013	10/3/2013	11/3/2013	43.25	2	45.25	16	61.25	1	7	0
Nataral-EZ	300000	1,000's	31/3/2013	12/3/2013	13/3/2013	59.25	2	61.25	12	73.25	1	3	0
Orkelax	100000	50x10's	31/3/2013	12/3/2013	15/3/2013	55.25	3	58.25	12	70.25	1	3	0
Orkelax	100000	50x10's	31/3/2013	13/3/2013	16/3/2013	60.25	10	70.25	12	82.25	1	3	0

Figure 4. Recalculation of completion time after overtime entry at given order and date

RESULTS AND CONCLUSION

By testing at one of the small pharmaceutical company, the feedback from production planner was very positive. The DSS allows planner to quickly response to several scenarios that often occur such as rush order, schedule adjustment due to machine malfunction, order promise date quotation. While the system is designed to help planner to lower the cost of overtime, responsive quotation (rush order) with minimal cost is a preferred way for planner. In addition, a daily feedback (as shown in Figure 5) from shop floor is crucial for the accuracy of information by DSS. Therefore, these can lead to a suggestion for DSS developer to integrate factory execution system into DSS for better accuracy and responsiveness.

Figure 5. Factory execution system reporting

REFERENCES

1. Lingitz, L et. al. (2013) "Modelling of Flexibility Costs in a Decision Support System for Mid-term Capacity Planning", Procedia CIRP, Vol. 7, 2013, pp. 539-544
2. Lutz, M., Boucher, X. and Roustant O. (2012), "Information Technologies capacity planning in manufacturing systems: Proposition for a modelling process and application in the semiconductor industry", Computers in Industry, Vol. 63, Issue 7, September 2012, pp. 659-668
3. Sundaramoorthy, A., et. al. (2012), "Capacity Planning for Continuous Pharmaceutical Manufacturing Facilities", Computer Aided Chemical Engineering, Vol. 31, 2012, pp. 1135-1139
4. Vollmann, T. E., Berry, W. L., Whybark, D. C. and Jacobs, F. R. (2008), "Manufacturing Planning and Control for Supply Chain Management", McGraw-Hill Education (Asia), Singapore.

ASSESSING THE SOCIAL IMPACT FACTORS OF THE ON-LINE GAMBLING IN CHINESE SOCIETY

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ABSTRACT

Gambling is a crucial issue ethically. Many researches in the US noticed that many problem gamblers came from Nevada. Recently, Asian countries also start to emphasize the pathological issues. They are crime, family problems, and new generation issues. The present study will adopt the Analytical Hierarchy Process, and develop an expert questionnaire to survey police generals, experts among Taiwan. The above three main factors, and sub-factors may be concluded bellowed. The present study will also survey the valuable ethical opinions from police generals and experts in China. After that, it will compare the advantages of legalized casino and various disadvantages from illegal gambling (concentrating on the on-line gambling behaviors).The present study plan to adopt the Analytical Hierarchy Process Method, especially, this method is quite ideal for evaluating the real world today since it consist of a set of complex interrelated issues .

The expected contribution of this research is trying to conclude the significant factors of the illegal casino (or gambling) and its ratio. Hopefully, it will contribute to the development of the future Gaming Industry in Taiwan.

Keywords: Gaming Industry, social impacts, on-line gambling, Chinese gambling behavior

THE RELATIONSHIPS AMONG LEADERSHIP STYLES, SUBORDINATE MATURITY, INFORMATION DISTINCTION AND IMPLICATIONS FOR MULTINATIONAL TAIWANESE ORGANIZATIONS

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ABSTRACT

Most leadership theories focus on leader's development. However, in reality, the led is also very important in the leadership process. Development relates to ensure the individual to grow in the skills, knowledge, and abilities to perform at leaders' highest possible level now and for the future. The topic area of the relationships among leadership styles, subordinate maturity, and information distinction was identified because it is a practical problem and personal experiences occurring in multinational corporations. Some questions to be answered through this critical analysis of the literature are: (1) What are the effective leadership styles in the leader-member and member-member relationships? (2) How do the subordinates react to leaders' managerial style? (3) What are the relationships among leadership styles, subordinate maturity, and resulting information distinction? (4) What kinds of information distinction effects the relationships between leadership styles and subordinate maturity? (5) Where do leaders and subordinates can get information, and how? (6) In what areas are leaders' or subordinates' knowledge weakest, and how can they get others to prove the information they need? (7) How important is that information to the subordinates? (8) Do the leaders keep too much information for their subordinates because it is inconvenient? The main purpose of this review is to explore the theoretical and empirical literature about the relationships among leadership style, subordinates maturity, and information distinction implications in multinational Taiwanese organizations to identify areas of future scholarly inquiry.

Keywords: Leadership Style; Subordinate Maturity; Information Distinction; Multinational Organization.

INTRODUCTION

Leadership is the most popular topics in the social science and often used the word describing a successful organization. The managerial behaviors that cause the effective leadership become more critical for the rapid changes of workforce, the world into the information era, and the change of the global environment impact on the whole world (Adeyemi, 1999). The 21st century is a competitive century, and one way to gain a competitive advantage is for leaders to value the assets of employees and adapt their styles in decision-making (Eguchi, 2000, p.2). Leaders should adapt different behavior to achieve the goal of the tasks. Leadership was considered as the supportive and leadership styles with the communication and permissiveness to enhance creativity, and emphasizing telling and directing for getting the work done (Yeh, 1995). To inspirit the employees fulfill themselves and utilize the information distinction, leaders should adapt applicative leadership styles (Eguchi, 1999, p. 4). Different conditions influence subordinates' judgment and perceptions about the sense of self-esteem and satisfaction (Yammarino & Dansereau, 2002). The managers can directly effort inside the unit of the organizations and external world. There two roles at the information level. First role is communicating which seeking and receiving information with others inside the organization as disseminator or externally as spokesperson. Second role is controlling that use information control the work condition to design the structures, and to develop the procedures in the organization (Mintzberg, 2002). There are several reasons to motive a firm to pursue international business: (1) motive globalization; (2) environmental change; (3) the firm is able to increase its revenues and profits; (4) acquiring resources; (5) seeking new markets; (6) better competing with industry rivals by the ways to enter foreign market; and (7) improvements in communications, transportation, and information processing making international business more feasible and profitable (Strikwerda, 2003).

Leadership is a leader who has followers, the ability to influence people, and taking effective action to realize leadership potential (Roof, and Presswood, 2004). Leonard, Beauvais, and Scholl (1999) defined the leadership styles that are task leadership and social-emotion leadership. Maturity was defined as the subordinates' willingness to accept responsibility, abilities, and experience. Subordinate maturity that is directive, relationship, supportive, and delegating (Baird, Post, and Mahon, 1990, p. 308-309) . Hersey, Blanchard, and Johnson (2000) also defined the subordinate maturity is the capability to achieve the organizational mission and subordinate's loyalty. Mintzberg, (1998) described information roles of managerial work that are monitor role, disseminator role, and spokesperson role. Hershey and Blanchard also identified the leadership needed for each situation or quadrant. Information distinction of an organization's information includes message, data, and knowledge (Swift & Huang, 2004). Duncan, LaFrance, and Ginter, (2003) described the Vroom-Yetton model that autocratic decision-making when leaders have the necessary information to solve the problem and additional information is obtained from the subordinates before leader makes decision. Both the leadership and the maturity level of the

employees are Situation theory is a contingency with a focus on the followers (Robbins, 2002). Hersey, Blanchard, and Johnson, (2000) suggests that as employees mature, the leadership style moves from task-motivated to relationship-motivated situational leadership style. Four situational leadership styles are telling, selling, participating, and authorizing. The Fiedler contingency theory effects that the group performance between leadership style and the situation gives control to the leaders (Robbins, 2002, p.320). Robbins, (2003) described the path-goal theory is the leader's job to collaborate the followers in the goals and provide the direction to ensure the goals are harmonious with the objectives of the organization. Hersey, Blanchard, & Johnson, (2000) added subordinate maturity variable in the situational leadership model, so the subordinate maturity's definition is the subordinate's capability to achieve the organization' mission and subordinate's loyalty. Campbell, (2000) explained the followership that focus two types of behavior-independent thinking and active engagement on the employee role. Sherman, (2002) defined the leader member exchange that how leader role inversion causes in a reconfiguration of role pressures, and presumes that the reconfiguration of the role will affect the work-related attitudinal and behavioral outcomes.

The causal (independent) variables are information distinction, and subordinates maturity. Subordinate maturity structures include followership, social exchange theory, and situational leadership model. Leadership styles are the outcome. The topic area of the relationships among leadership styles, subordinate maturity, and information distinction was identified because it is a practical problem and personal experiences occurring in multinational corporations.

Some questions to be answered through this critical analysis of the literature are:
A. What are the effective leadership styles in the leader-member and member-member relationships?
B. How do the subordinates react to leaders' managerial style?
C. What are the relationships among leadership styles, subordinate maturity, and resulting information distinction?
D. What kinds of information distinction effects the relationships between leadership styles and subordinate maturity
E. Where do leaders and subordinates can get information, and how?
F. In what areas are leaders' or subordinates' knowledge weakest, and how can they get others to prove the information they need?
G. How important is that information to the subordinates?
H. Do the leaders keep too much information for their subordinates because it is inconvenient?

The problem area of leadership styles, subordinate maturity and information distinction is about the practices in the leader's behavior, subordinates and relationship of information between leadership styles and subordinate maturity. The purpose of this critical analysis of the theoretical and empirical literature is to explore the relationship among leadership,

subordinates maturity, and information distinction implications for multinational Taiwanese organizations, and to identify areas of future scholarly inquiry.

REVIEW OF LITERATURES

Leadership styles

Leonard, Beauvais, and Scholl (1999) defined the leadership styles that are task leadership and social-emotion leadership. Hersey, Blanchard, and Johnson, (2000) described four leadership styles of telling, selling, participating, and authorizing in their situational leader model. In the past few years, many scholars have concentrated the efforts on interpersonal relationships of people working together in an organization. Leader-member exchange theory emphasize how leaders can use influence and with different leadership styles in supervision of different kinds of subordinates (Wong & Wong, 2003). Using path-goal theory, it is the leader's responsibility to collaborate with followers in the goals and provide the direction to ensure the goals are harmonious with the objectives of the organization (Robbins, 2003).

Path-Goal Theory

The Path-Goal Theory that the leaders influence subordinates' perceptions, motivation, and ability to increases subordinates' working satisfaction, the subordinates' acceptance of the leader; and subordinates' expectations will effort organization performance (Hsu, Hsu, Huang, Leong, and Li, 2003). Hsu, Hsu, Huang, Leong, and Li, (2003) conducted empirical study examining the relationships between leadership style and turnover in Mainland China. The sample used a non-experimental, causal comparative and correlational survey design with 127 employee surveys of 306 employees. The surveys acceptable response rate was 41.50%. The literature review was thorough, current in comparing and contrasting theories about leadership styles. They used questionnaires to collect data, correlation and t-test to measure. Reliability estimates were not high enough for internal consistency and construct and criterion related validity is established. Data collection procedures were not very clearly described; however, IRB approval was not reported. Using refined scores, findings supported the hypothesis that the relationships between leadership style and turnover. Limitations reported by Hsu, Hsu, Huang, Leong, and Li are (1) Path-Goal leadership model can be placed in Mainland China. (2) the study is affected by the limitations of the differences between managerial and non-managerial employees in an organization. Their findings are consistent with significant and negative correlation of the relationships between leadership styles and turnover. Future studies should conduct a longitudinal study about the effect of personality variables on leadership styles.

Contingency theory

Contingency theories take account of the task, the nature of the work group, and the position of the leader. It is an important theory that helps to understand and improve the relationships of individuals and groups (Hanbury, Sapat, and Washington, 2004). Campbell,

Dardis, and Campbell, 2003 considered that the design of the leadership style need to choose subordinates maturity of development level. The development level includes job objective and aspiration skills, working experiences or training, communication, information of feedback, and self-evaluation. To value congruence, selection has leadership potential by focusing on the core influence skills. The Situational Leadership Model intended to become more effective in how the followers based on differing follower characteristics, and how leadership effectiveness may depend on being flexible with different subordinates. Leaders and followers must assume full responsibility for building quality into all aspects of their work in the organizations (Grover & Walker, 2003).

The Ohio State University Studies

The Ohio State University and University of Michigan Studies are the two most important approaches in the behavior leadership (Muchinsky, 2000). The initial task of the Muchinsky was to develop questionnaires for subordinates to describe their leaders' behavior. Muchinsky compiled a list to 150 items of 1800 examples of leadership functions. The questionnaire responses indicated that subordinates perceived their behavior primarily in terms of consideration and initiating structure. Based on the results of the initial studies, the LBDQ, SBD, LOQ, and LBDQ XII questionnaires were constructed to measure consideration and initiating structure. The results have been weak and inconsistent of leadership effectiveness; the finding was positive relationships between consideration and subordinate satisfaction. Limitations reported by Muchinsky is leadership questionnaires have a fixed response format that requires respondents to think back over a period of the time, and indicate how often leaders used the behavior described in an item.

The University of Michigan Studies

The University of Michigan Studies is similar with Ohio State Leadership Studies. The studies include production-oriented and employee-oriented of the two dimensions leadership behavior. Leaders who were the employee-oriented were described as emphasizing interpersonal relations, associated with high group productivity and job satisfaction. The production-oriented emphasize technical or task aspects of the job, and tend to associated with low group productivity and lower job satisfaction. (Robbins, 2003).

Leadership behaviors

Leadership behaviors effect to create change within the organizations. Through co-operation to knowledge of the internal leadership provides education and training with leaders and subordinates, and providing feedback and support with the decision making (Boehnke, Bontis, DiStefano, & DiStefano, 2003). Boehnke, Bontis, DiStefano, & DiStefano, (2003) conducted empirical research and Meta analyses indicate that leadership styles have differential effects on individual performance. The questionnaire responses indicated that transformational leadership characteristics are associated with higher performance and positive effects of rewarding behavior in the transactional mode. Based on the results of the initial studies, the MLQ and LBI questionnaires were constructed to measure leadership.

They used t-test to find significant differences in the leadership behavior across the national clusters. Data collection procedures were not clearly described; however, IRB approval was not reported. Their finding of teamwork is an essential component of success within corporate settings. Future studies should be encouraging all leaders to use transformational behavior to generate this individual performance.

Hersey, Blanchard, and Johnson, (2000) identify telling; selling, participating, and authorizing are the four types of leadership styles in the situational leadership model. Grover, & Walker, (2003) described the Situational Leadership Model focus on the needs of followers. Leaders need to modify their actions to fit the ability and willingness, and let their followers to perform their work. The Situational Leadership Model prescribes a style of leadership to meet the needs of followers. McCauley, & Velsor, (2003) identified the leader styles include using high standards to inspire the subordinates around the organizations' vision of performance style, instill the pride and loyalty of group style, encourage subordinates and equality of participative style, emphasize procedural behavior of self-protection, and supportive style. Harrell (2003) indicates that a leader should be communicate the organization's vision and plan with subordinates, understand what the subordinates are thinking and what they need, and avoid hidden agendas and destructive conflict in the organizations. Krass, (1998) discuss personal attractiveness, decision making, a sense and interest of persuasiveness, responsibility, and intellectual ability of the qualities of leaders. George, (2000) analyzed emotional intelligence extent the leaders accurately knowledge perceives and to influence subordinates' emotions, so emotional intelligence has the potential to effective leadership.

Subordinates Maturity
Job maturity and psychological maturity
Hersey, Blanchard, and Johnson (2000) added subordinate maturity variable in the situational leadership model, so the subordinate maturity's definition is the subordinate's capability to achieve the organization' mission and subordinate's loyalty. Hersey, Blanchard, and Johnson, (2000) described four leadership styles which that the telling, selling, participating, and authorizing with the situational leader model. And they proposed a contingency theory that prescribes different leadership behavior on the maturity of an individual subordinate. Maturity includes two components: (1) job maturity is a subordinate's task relevant skills and technical knowledge, (2) psychological maturity is the subordinate's sell-confidence and self-respect. A high subordinate maturity has the ability to do their job, and assume more responsibility. A low subordinate maturity lacks ability and self-confidence. As subordinate maturity increase from the minimum amount up to a moderate level, the leaders should use more relations behavior and less task behavior. Four degrees of subordinate maturity are distinguished. When a subordinate is immature in relation to the task (M1), the leaders should concentrate on task oriented behavior and defining subordinate roles and establishing objectives, standards, and procedures. When a subordinate has a moderate amount of maturity (M2 and M3), the leaders consult with the subordinate in decision

making, and provide praise and attention. When subordinate is mature (M4), the leaders should authorize responsibility for the considerable autonomy. A mature subordinate has the ability to work without direction from the leaders, and the confidence to work without supportive behavior by the leaders. According to Hersey, Blanchard, and Johnson, the maturity level of subordinates can be influence by developmental interventions. A simple developmental intervention for subordinates consists of relaxing the direction and delegating more responsibility for a special task. If subordinates respond positively, the leaders should provide praise and emotional support to the subordinates. Hersey, Blanchard, and Johnson recognize that subordinates maturity may regress, requiring a flexible adjustment of the leaders' behavior. They advanced the proposition that leaders should be aware of opportunities to build the skills and confidence of subordinates, rather than assuming a subordinate with deficiencies in skills. Yukl, (1998) described the level of subordinate maturity with situational leadership theory determines the optimal illustration of leader behavior. Subordinates have the ability to work without leaders' information or order, and use the self-confidence to work without leaders' support. The Hersey and Blanchard Contingency Theory influenced development level of subordinates' maturity, and required a flexible adjustment of the leaders' behavior.

Subordinates' perception of the leaders

Dotlich, & Cairo, (2002), described the trust is the natural leadership that people receive in the organizations, and through the classified information to improve themselves with the responsibility. Trust is also the relationships between performance levels and subordinates, and accelerates the delivery of work. Kelley, (1992) the research's results are different with traditional leadership, the researchers believe that superior adopt selective influence with some subordinate, and use authority's supervision to another subordinate. Gibson, & Pason, (2003) conducted methodological study examining the effectiveness of an innovative levels of leadership. The sample used self-report measures of orientations with 123 students. They used PLP to measure students' responsibilities and challenges of leadership. In the 66 first-years, Gibson, & Pason administered assessment batteries, eighty-eight of 132 batteries were returned, and return rate was 67%. They also administered a similar battery, thirty-five of 41 batteries were completed, and the return rate was 85%. The literature review was thorough, current in comparing and contrasting theories about followership. They used students' orientations to collect data. Data collection procedures were not very clearly described; however, IRB approval was not reported. Gibson, & Pason findings are the students were selected for PLP according to their commitment to service work, and students gave the highest ranking to a less developmentally advanced dimension. Future studies should contemplate for advancing education in leadership development.

Dixon, and Westbrook, (2003) identified the follower that unquestioningly obeying leader's command is no longer viable for the competitiveness of a global organizations. Followers should be understood partners and participants in the pursuit of productivity in the organization. Campbell, (2000) explained the followership that focus two types of behavior-

independent thinking and active engagement on the employee role. Townsend, and Gerhardt, (1997) described that followership is a continuing role, and is a joint responsibility share by individuals and the organizations. Followership also as a process of subordinates recognizes the responsibility with leaders and action consistent with the situation to carry out those leader's orders to the best of subordinates' ability.

Leader-member exchange

Yukl, (1998) described the role making process between leaders and subordinates. The basic premise of the theory is that leaders develop a separate exchange relationship with subordinates. Most leaders establish a special exchange relationship with the trusted subordinates that are called in-group who function as assistants, or advisors. The exchange relationship with the remaining subordinates of out-group is substantially different. In the exchange relationship with out-group subordinates, there is a relatively low level of mutual influence. The primary source of leader influence is legitimate authority with coercive power and reward power. In-group subordinates are expected working hard, more committed to the task objective, be loyal to the leaders, and share the leaders' administrative duties. Graen, & Uhl-Bien, (1995) defined and measures the quality of relationship is assumed to involve mutual trust, respect, affection, and loyalty. The scale used LMX-7 for the research, and used more diverse questionnaires in an attempt to identify separate dimensions of LMX. It's not clear the scales offer any advantages over a single scale measuring the quality of leadership. The major limitation is leader subordinate exchange has been too much reliance on static field studies with questionnaires. Future studies should include more intensive measures to supplement the usual questionnaires. Liden, and Maslyn, (1998) emphasis that the multiple dimensions of leader-member exchange include loyalty, contribution, and affect. Different leader-member exchange that influence perceptions of organizational justice in the organizations. Sparrow and Liden, (1997) considered the leader-member exchange that the relationships between leader and subordinate will change with different situations.

Information Distinction

Swift & Huang, (2004) identified the information distinction that organization information includes message, data, and knowledge. Yukl, (1998) mentioned that communication of task relevant information needed by leaders, and subordinates. Subordinates are kept information about developments in the organizations are likely to have greater job satisfaction. Information includes different communication of message and data. Caldwell and Clapham, (2003) described individuals perceptions about organizations based on the information about the organization and experiences with the organization.

Decision making

The Vroom-Yetton Model that autocratic decision-making when leaders have the necessary information to solve the problem and additional information is obtained from the subordinates before leader makes decision (Duncan, LaFrance, and Ginter, 2003). Duncan, LaFrance, and Ginter, (2003) conducted methodological study, and their data collection

includes six engagements of the American Civil War. Their questionnaires are the autocratic decision-making when leaders have the necessary information and good support and morale from the troops. The literature review was thorough, current in comparing and contrasting theories about leader subsequently uses information to determine an approach in a particular decision making situation. IRB approval was not reported. Results reported by Duncan, LaFrance, and Ginter are (1) there is the relevant relationship amount information, leadership, and decision making. (2) the leadership style advocated by the potential advantages of decision making. Future studies should examine different military conflicts and more dynamic decision making environments.

Vroom and Yetton's model

Irving, & Meyer, (1997) prescribes the managerial decision making that varies of subordinate participation in a decision with Vroom and Yetton's model. Irving, & Meyer conducted empirical study examining the underlying dimensions of managerial conflict on the Vroom - Yetton model of managerial decision making. The samples were 128 males and 227 females of 356 individuals who participated either for the introductory psychology course or an organizational behavior class exercise at a large Canadian university. These individuals' age ranged from 18 to 51 years, with a mean of approximately 21 years. From the total samples, 41.6% individuals had some full time work experience, 328 individuals had part time work experience, 44.1% individuals had supervisory experience, and 188 individuals indicated that they had to intervene in a conflict between two individuals in the past. The literature review was thorough, current in comparing and contrasting Vroom - Yetton model about conflict arbitration strategies that a manager may use. Data collection procedures were clearly described; however, IRB approval was not reported. They using the theoretically and empirically dimensions of conflict arbitration strategies related to the dimensions derived from the MDS analysis. Limitations reported by Irving, & Meyer are (1) the publicly versus privately dimension would have emerged from the dimensional structure. (2) the study of the university students were consistent with recent characterizations of the dimensions of conflict intervention strategies. Their findings are (1) two dimensions of managerial third party conflict highly similar to Vroom and Yetton's model of participative versus autocratic decision making. (2) managers not only make decisions, but also concerning managers will become involved in the dispute. Future studies should question managerial conflict intervention strategies might employ other methodologies.

Information collection

Yan, (2003) emphasized that the main duty of the leader is to lead organization to interact with the environment and the competitors. The information collection is to predict the change and development in the organization, and the subordinates are the main channel to get particular and critical information. Michaelson, (2001) p.125-133 discuss that the process of information is collecting and filtering, the key decision is how to select the information flow to management levels. To make information useful, leaders and subordinates have to put information together to form distinct patterns to inform all management levels.

Information operation system

Tractinsky, and Jarvenpaa. (1995) described organizational information can be analyzed rational perspective and behavioral. Behavioral perspective tends to emphasize how organizational gain influence and the relationship among information distribution policy, organizational power and control structures. The rational perspective emphasizes how to maximum of the organizational benefits. An effective information system is presumably one that fits the political and rational characteristics. Tractinsky, and Jarvenpaa. (1995) conducted empirical study on distribution decisions focus on the IT distribution and its correlations with other organizational decision making structure. The samples were 33 items of IT applications' hardware, software, and data. The literature review was thorough IT distribution issues is that organizations operate in a relatively environment. Data collection procedures were clearly described; however, IRB approval was not reported. Implications reported by Tractinsky, and Jarvenpaa is global firms wish to improve the systems, and challenged global project managers by the global contexts' complexity. Their limitations are (1) domestic project managers might have been exposed their global context and they were all from multinational American manufacturing industries. (2) firms are relatively highly decentralized global companies Future studies should explore different organizational global IT system operation.

Information role

Mintzberg, (2002) described the virtue of interpersonal contacts both with subordinates and a network, the managers emerge the center of organizational unit. The managers may not know everything, but typically knows more that subordinates. His studies have shown the relationship between the interpersonal and informational roles. Processing information is a key part of managers' job. In Mintzberg's study, the CEOs spent 40% of the time on activities devoted exclusively to the transmission of information; 70% of their incoming mail was purely informational. In large part, communication is CEOs work. The samples were 890 pieces of incoming and outgoing mail and 368 verbal contacts of five American organizations. Mintzberg used a structural observation method, during one intensive week of observation for each executive. Three roles describe the informational aspects of managerial work. (1) As monitor, the managers are scanning the environment for information; cross-examine liaison contacts and subordinates, and receiving information of personal contacts. (2) In the disseminator role, the managers pass information directly to subordinates. When subordinates lack easy contact with one another, the managers may pass information from one to another. (3) In the spokesperson role, every manager must inform and satisfy the influential people who control the organizational units.

Phillips, (1998) conducted a quantitative, meta-analysis study to explore the information processing system, and organized favorable and unfavorable job-related information to specific related information of information types. The authors presented four hypotheses: (1) Realistic job previews in laboratory and field settings will be related to lower

turnover, process, and commitment of performance. (2) More positive affect and job expectations, greater performance, and lower turnover than realistic job previews information in a early recruitment process. (3) Videotaped realistic job previews will have a stronger, positive relationship with performance than verbal and written realistic job previews. (4) Verbal realistic job previews will have a stronger, positive relationship, and written realistic job previews will have the weakest relationships with all criteria. The sample size was a total of 40 studies of realistic job previews. Hypotheses were tested with three characteristics of realistic job, timing, and the effects on organizational outcomes. The findings of RJPs were slightly, negatively related with RJPs might influence organizational outcomes. The results suggest that RJPs are related to lower levels of the employment process, expectations, turnover, and higher performance.

Multinational organizations

Ball et al. (2003) described three challenges facing firms when first addressing the international market place that are: (1) a company that operates in the global market must be concerned with the effects of it home land and the land outside its borders. (2) The major issue with the foreign environment is that the problems a difficult to access, especially their legal and political elements. (3) Balancing the challenges between the controllable and uncontrollable forces.

Galbraith, (2000) described numerous reasons for firms to elect to pursue global business ventures. Technological advances have created tremendous communication opportunities. The global market has opened wide, and companies may want to take advantage of the expanded market. The ease of communicating with areas in various locations around the world has made it easier for companies to locate their operations in different companies, taking advantage of competitive advantages like access to resources, different political and economic restrictions, and the opportunity to save money on labor, land, and utilities. Companies can benefit from the training of personnel in different areas of the world, and they can bring their product lines to locations where they can meet the needs and wants of populations and be profitable without restricting themselves to one specific geographical area. Galbraith lists several challenges companies may encounter when competing in the global market. These include the number of different countries involved, varying currencies, tax policies, different languages and customs, cultural and religious differences, time zones, geographical and environmental issues, security, and governmental changes and conflicts. Additionally, Galbraith mentions the difficulty some companies have in recreating competitive advantages when they try to relocate production or distribution to other countries. To overcome this difficulty, companies must first uncover what the source of their competitive advantage is and then determine whether that can be transferred to another country or site. Geopolitical uncertainty, primarily caused by political unrest, adds much challenge to global organizations. Even if businesses try to separate themselves from the politics of the countries in which they conduct business, they can still be linked through boycotts and they can still suffer the consequences of trade embargos, worker boycotts and

strikes, and governmental interference, not to mention the hardships that come with unrest such as building destruction, loss of access to transportation and utilities, loss of life, or change in the amount of support for the company from the host country. Finally, customers are complex, and their needs vary individually as well as globally or regionally. Customers are likely to form affiliations with some companies, sometimes on a countrywide basis, and then products and services can be linked or eliminated from good opportunity on the basis of those affiliations. People in different countries may have varying needs and they respond to marketing campaigns differently. From a company perspective, strategic management and managing through change become more difficult, and training people who speak different languages and have different customs is an added challenge.

SUMMARY AND INTERPRETATIONS

The purpose of this critical analysis of the theoretical and empirical literature is to explore the relationship among leadership, subordinates maturity, and information distinction implications for multinational Taiwanese organizations, and to identify areas of future scholarly inquiry. The organization of this summary and interpretations is according to "selected and pertinent themes" from the author's literature map, which also organized the body of the review. The major findings of this literature review are that leadership styles, subordinate maturity and information distinction is about the practices in the leader's behavior, subordinates and relationship of information between leadership styles and subordinate maturity. The next two areas are theoretical literature and empirical literature, which aim to present a synopsis of the state-of-the-art of the theoretical literature and empirical literature about the topic and let the reader know what is known and unknown.

Theoretical Literature
    Leadership style. The theoretical literature about Hersey, Blanchard, and Johnson, (2000) described four leadership styles of telling, selling, participating, and authorizing in their situational leader model. In the past few years, many scholars have concentrated the efforts on interpersonal relationships of people working together in an organization. Leader-member exchange theory emphasize how leaders can use influence and with different leadership styles in supervision of different kinds of subordinates (Wong & Wong, 2003). Contingency theories take account of the task, the nature of the work group, and the position of the leader. It is an important theory that helps to understand and improve the relationships of individuals and groups (Hanbury, Sapat, and Washington, 2004). Campbell, Dardis, and Campbell, 2003 considered that the design of the leadership style need to choose subordinates maturity of development level. The development level includes job objective and aspiration skills, working experiences or training, communication, information of feedback, and self-evaluation. Grover, and Walker, (2003) described the Situational Leadership Model focus on the needs of followers. Leaders need to modify their actions to fit the ability and willingness, and let their followers to perform their work. The Situational Leadership Model prescribes a style of leadership to meet the needs of followers. McCauley, & Velsor, (2003) identified the

leader styles include using high standards to inspire the subordinates around the organizations' vision of performance style, instill the pride and loyalty of group style, encourage subordinates and equality of participative style, emphasize procedural behavior of self-protection, and supportive style.

Subordinates maturity. Hersey, Blanchard, and Johnson, (1996) added subordinate maturity variable in the situational leadership model, so the subordinate maturity's definition is the subordinate's capability to achieve the organization' mission and subordinate's loyalty. Hersey, Blanchard, and Johnson, (2000) described four leadership styles which that the telling, selling, participating, and authorizing with the situational leader model. And they proposed a contingency theory that prescribes different leadership behavior on the maturity of an individual subordinate. Maturity includes two components: (1) job maturity is a subordinate's task relevant skills and technical knowledge, (2) psychological maturity is the subordinate's sell-confidence and self-respect. A high subordinate maturity has the ability to do their job, and assume more responsibility. A low subordinate maturity lacks ability and self-confidence. Yukl, (1998) described the level of subordinate maturity with situational leadership theory determines the optimal illustration of leader behavior. Subordinates have the ability to work without leaders' information or order, and use the self-confidence to work without leaders' support. The Hersey and Blanchard Contingency Theory influenced development level of subordinates' maturity, and required a flexible adjustment of the leaders' behavior. Dixon, and Westbrook, (2003) identified the follower that unquestioningly obeying leader's command is no longer viable for the competitiveness of a global organizations. Followers should be understood partners and participants in the pursuit of productivity in the organization.

Leader-member exchange.   Yukl, (1998) described the role making process between leaders and subordinates. The basic premise of the theory is that leaders develop a separate exchange relationship with subordinates. Most leaders establish a special exchange relationship with the trusted subordinates that are called in-group who function as assistants, or advisors. The exchange relationship with the remaining subordinates of out-group is substantially different. In the exchange relationship with out-group subordinates, there is a relatively low level of mutual influence. The primary source of leader influence is legitimate authority with coercive power and reward power. In-group subordinates are expected working hard, and more committed.

Information distinction.   Yukl, (1998) mentioned that communication of task relevant information needed by leaders, and subordinates. Subordinates are kept information about developments in the organizations are likely to have greater job satisfaction. Information includes different communication of message.

Decision making.   The Vroom-Yetton Model that autocratic decision-making when leaders have the necessary information to solve the problem and additional information is

obtained from the subordinates before leader makes decision (Duncan, LaFrance, and Ginter, 2003).

Information collection.   Yan, (2003) emphasized that the main duty of the leader is to lead organization to interact with the environment and the competitors. The information collection is to predict the change and development in the organization, and the subordinates are the main channel to get particular and critical information.

Empirical Literature

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Subordinates maturity.   Campbell, (2000) explained the followership that focus two types of behavior-independent thinking and active engagement on the employee role. Townsend, and Gerhardt, (1997) described that followership is a continuing role, and is a joint responsibility share by individuals and the organizations. Followership also as a process of subordinates recognizes the responsibility with leaders and action consistent with the situation to carry out those leader's orders to the best of subordinates' ability.

Leader-member exchange.   Graen, & Uhl-Bien, (1995) defined and measures the quality of relationship is assumed to involve mutual trust, respect, affection, and loyalty. Liden, and Maslyn, (1998) emphasis that the multiple dimensions of leader-member exchange include loyalty, contribution, and affect. Different leader-member exchange that influence perceptions of organizational justice in the organizations. Sparrow and Liden, (1997) considered the leader-member exchange that the relationships between leader and subordinate will change with different situations.

Information distinction.   Swift & Huang, (2004) identified the information distinction that organization information includes message, data, and knowledge. Caldwell and Clapham, (2003) described individuals perceptions about organizations based on the information about the organization and experiences with the organization.

Decision making.   Irving, & Meyer, (1997) prescribes the managerial decision making that varies of subordinate participation in a decision with Vroom and Yetton's model.

Information collection.   Michaelson, (2001) p.125-133 discuss that the process of information is collecting and filtering, the key decision is how to select the information flow to management levels. To make information useful, leaders and subordinates have to put information together to form distinct patterns to inform all management levels.

Information operation system.   Tractinsky, and Jarvenpaa. (1995) described organizational information can be analyzed rational perspective and behavioral. Behavioral perspective tends to emphasize how organizational gain influence and the relationship among information distribution policy, organizational power and control structures. The rational perspective emphasizes how to maximum of the organizational benefits. An effective information system is presumably one that fits the political and rational characteristics.

Informational role.   Mintzberg, (2002) described the virtue of interpersonal contacts both with subordinates and a network, the managers emerge the center of organizational unit. The managers may not know everything, but typically knows more that subordinates. His studies have shown the relationship between the interpersonal and informational roles. Processing information is a key part of managers' job.

Multinational organizations.   Ball et al. (2003) described three challenges facing firms when first addressing the international market place that are: (1) a company that operates in the global market must be concerned with the affects of it home land and the land outside it borders. (2) the major issue with the foreign environment is that the problems a difficult to access, especially their legal and political elements. (3) balancing the challenges between the controllable and uncontrollable forces.

CONCLUSIONS

Theoretical

In the past few years, many scholars have concentrated the efforts on interpersonal relationships of people working together in an organization. Leadership style need to choose subordinates maturity of development level. Subordinates have the ability to work without leaders' information or order, and use the self-confidence to work without leaders' support. The relevant information needed by leaders, and subordinates. (Hersey, Blanchard, and Johnson, 2000; Yukl, 1998).

The theoretical literature on leadership style, subordinates maturity, and information distinction approaches to multinational organizations by Hersey, Blanchard, and Johnson, (2000) provides four leadership styles of telling, selling, participating, and authorizing in their situational leader model to meet the needs of followers. According to Yukl (1998),

Hersey and Blanchard Contingency Theory influenced development level of subordinates' maturity, and required a flexible adjustment of the leaders' behavior. Duncan, LaFrance, and Ginter, (2003) discuss the Vroom-Yetton Model that autocratic decision-making when leaders have the necessary information to solve the problem and additional information is obtained from the subordinates before leader makes decision.

Empirical

Leadership behaviors effect to create change within the organizations. Through co-operation to knowledge of the internal leadership provides education and training with leaders and subordinates, and providing feedback and support with the decision making (Boehnke, Bontis, DiStefano, & DiStefano, 2003). Townsend, and Gerhardt, (1997) described that followership is a continuing role, and is a joint responsibility share by individuals and the organizations. Mintzberg, (2002) have shown the relationship between the interpersonal and informational roles. The managers may not know everything, but typically knows more that subordinates.

REFERENCES

1. Ball, D., McCulloch, W., Geringer, M., Frantz, P., and Minor, M. (2003). International business: The challenge of global competition (9th ed.): McGraw-Hill.
2. Boehnke, K., Bontis, N., DiStefano, J. J., & DiStefano, A. C. (2003). Transformational leadership: An examination of cross-national differences and similarities. Leadership & Organization Development Journal. Bradford: 24(1/2), 5, 11 pages.
3. Caldwell, C., and Clapham, S. E. (2003). Organizational trustworthiness: An international perspective. Journal of Business Ethics. 47(4), 349.
4. Campbell, D. J. (2000). The proactive employee: Managing workplace initiative. The Academy of Management Executive. 14(3),52, 15 pages.
5. Campbell, D. J., Dardis, G., & Campbell, K. M. (2003). Enhancing incremental influence: A focused approach to leadership development. Journal of Leadership & Organizational Studies. Flint: 10(1), 29.
6. Dixon, G. and Westbrook, J. (2003). Followers Revealed. Engineering Management Journal, 15(1), 19-25.
7. Dotlich, D. L., & Cairo, P. C. (2002). Unnatural leadership: Going against intuition and experience to develop ten new leadership instincts. San Francisco, CA.: Jpssey-Bass.
8. Duncan, W. J., LaFrance, K. G., & Ginter P. M. (2003). Leadership and decision making: A retrospective application and assessment. Journal of Leadership & Organizational Studies. 9(4), 1.
9. Galbraith, Jay R. (2000). Designing the Global Corporation. San Francisco: Jossey-Bass, Inc.
10. George, J. M. (2000). Emotions and leadership: The role of emotional intelligence. Human Relations. New York: 126(3), 269, 24 pages.

11. Gibson, F. W., & Pason, A. (2003). Levels of leadership: Developing leaders Through new models. Journal of Education for Business. 79(1), 23.

12. Graen, G. G., & Uhl-Bien, M. (1995). Relationship-based approach to leadership: Development of leader-member exchange (LMX) theory of leadership over 25 years: Applying a multi-level multi-domain perspective. Leadership Quarterly, 6(2), 219-247.

13. Grover, R. A. & Walker, H. F. (2003). Changing from production to quality: Application of the situational leadership transtheoretical change models. The Quality Management Journal. Milwaukee: 10(3), 8.

14. Hanbury, G. L., Sapat, A., & Washington, C. W. (2004). Know yourself and take charge of your own destiny: The "fit model" of leadership. Public Administration Review. Washington: 64(5), 556, 11 pages.

15. Harrell, K. (2003). The Attitude of Leadership: Taking the Lead and Keeping It. Hoboken, NJ.: John Wiley & Sons, Inc.

16. Hersey, P., Blanchard, K. H., & Johnson, D. (2000). Management of organizational behavior: Utilizing human resources (8th ed.). Englewood Cliffs, NJ: Prentice-Hall.

17. Hsu, J., Hsu, J. C., Huang, S. Y., Leong, L. L., & Li, A. M. (2003). Are leadership styles linked to turnover intention: An examination in Mainland China? Journal of American Academy of Business, Cambridge. Hollywood: 3(1/2), 37.

18. Irving, P. G., and Meyer, J. P. (1997). A multidimensional scaling analysis of managerial third-party conflict intervention strategies. Canadian Journal of Behavioural Science. 29(1), 7.

19. Kelly, R. E. (1992). The power of followership: How to create leaders people want to follow and followers who lead themselves. New York, NY.: Doubleday Books.

20. Krass, P. (1998). The book of leadership wisdom: Classic writings by legendary Business leaders. New York, NY.: Wiley.

21. Leonard, N. H., Beauvais, L. L., and Scholl, R. W. (1999). Work motivation: The incorporation of self-concept-based processes. Human Relations. 52(8), 969, 30 pages.

22. Liden, R. C., and Maslyn, J. M. (1998). Multidimensionality of leader-member exchange: An empirical assessment through scale development. Journal of Management. 24(1), 43-72.

23. McCauley, C. D. & Velsor, E. V. (2003). The center for creative leadership handbook of leadership development (2nd ed.). San Francisco, CA.: Jossey-Bass.

24. Michaelson, G. A. (2001). Sun Tzu: The art of war for managers: 50 Strategic rules. Avon, MA.: Adams Media Corporation.

25. Mintzberg, H. (1998). The manager's job: Folklore and fact. Boston, MA.: Harvard Business School Publishing.

26. Muchinsky, P. M. (2000). Psychology applied to work. (6th ed.). Pacific Grove, CA.: Cole Publishing Co.

27. Phillips, J. M. (1998). Effects of realistic job previews on multiple organizational outcomes: A meta-analysis. Academy of Management Journal. 41(6), 673, 18 pages.

28. Robbins, S. P. (2003). Organizational behavior. (10th ed.). Upper Saddle River, NJ: Prentice Hall.

29. Sparrow, R.T., & R.C. Liden, (1997). Process and Structure in Leader-Member Exchange. Academy of Management Journal, 22, 522-552.

30. Swift, J. S., & Huang, Y. (2004). The changing nature of international business relationships and foreign language competence. Int. J. Management Practice. 1. 20 pages.

31. Tractinsky, N. and Jarvenpaa, S. L. (1995). Information systems design decisions in a global versus domestic context. MIS Quarterly. 19(4), 507, 28 pages.

32. Townsend, p., and Gerhardt, J. E. (1997). For service to work right, skilled leaders need skills in "followership". Leadership & Organization Development Journal. 17(4), 29.

33. Yan, D. D. (2003). How to well use the art of war. Taipei, Taiwan.: Kaihsin Management Consultants Co., LTD.

34. Yukl, G. (1998). Leadership in organizations. (4th ed.). Upper Saddle River, NJ.: Prentice-Hill.

INTRA-ORGANIZATIONAL KNOWLEDGE TRANSFER MECHANISMS FOR OPEN INNOVATION

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ABSTRACT

This study uses a case study design to investigate the questions of how firms use different types of knowledge transfer mechanisms within their firms to contribute to new service development. Empirical evidence was drawn 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. The present study found that case companies used a higher degree of information richness mechanism for transferring knowledge (regular meetings at different levels) to discuss new project requirements and to assess potential problems within a department and across departments. Moreover, the present study also found that multiple mechanisms for transferring knowledge are used between the head office of a case company and each convenience store before the launch of the new service launch at all the stores. Case companies used a lower degree of information richness mechanism for transferring knowledge (e.g. internal announcements and an operation manual) to quickly inform store staff and correspondingly adopted a higher degree of information richness mechanism for transferring knowledge (training by supervisors) to empirically teach store staff and confirm that they could operate the new service accurately. In conclusion, the present research used the concept of information richness to operationalize the capacity of knowledge transfer. Thus it offered a better understanding of the adoption of different degree of information richness mechanisms for knowledge transfer within case companies in different stages of new service development to contribute to innovation activities.

Keywords: Intra-organizational knowledge transfer mechanisms; Information richness; Open innovation.

Paper Type: Research paper

INTRODUCTION

The context of open innovation emphasizes the importance of collaboration beyond company boundaries to share related resources for value creation. Open business model can help a firm save development costs of innovation by tapping into external sources of knowledge and leveraging external knowledge in the firm's innovation process (Chesbrough, 2007). Based on the previous literature in open innovation, previous studies focused on identifying the different types of openness and the extent to which a firm can benefit from external

resource/knowledge to contribute to innovation (e.g. Lichtenthaler, 2008; Dahlander and Gann, 2010). Some studies further investigated the appropriate strategies/ practices firms need to adopt and the essential capabilities firms have to develop in the outside-in and inside-out perspectives of open innovation process (e.g. Lichtenthaler and Lichtenthaler, 2009; Bianchi et al., 2011). The above two aspects of open innovation literature mainly focused on identifying the adoption of inter-firm relations and further investigating the classifying firm's essential capabilities, decisions and attitudes for managing knowledge process at different levels (i.e. organizational level, project level and individual level) in the context of open innovation. However, the question of how a firm makes the valuable knowledge/resources flow freely to appropriate departments and individuals within a firm should be considered, because these kinds of important knowledge/resource do not automatically flow to the appropriate departments and individuals to contribute to new service development when the innovating firm cooperates with external firms. Based on the above knowledge gap in the context of open innovation, this research would focus on the following main research questions: 1) How do different types of knowledge transfer mechanisms should be adopted within a firm to coordinate new service development activities? And 2) Does the adoption of knowledge transfer mechanisms vary with different service developments? This study aims to contribute to the existing literature on new service development and the context of open innovation, providing insights into intra-organizational knowledge transfer mechanism in Taiwanese service sector.

The rest of the paper is set out in the following way: In the next section, the background literature on the context of open innovation and intra-organizational knowledge transfer mechanism is reviewed. The design and method of the research is then described, followed by a discussion of the findings, conclusions, theoretical contribution and practical implications.

LITERATURE REVIEW

The context of open innovation

The concept of open innovation has gained popularity in academic debate over recent years. Previously, Chesbrough (2003) proposed the concept of an open business model, as opposed to the traditional (closed) business model and argued that an open business model could help a firm reduce the development costs of innovation, shorten the time needed to enter a new market and thus make it easier to create value in a new product or service and bring additional value to a firm by collaborating with other companies. West and Gallagher (2006) proposed that 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. Although a firm can receive many benefit from open innovation, there are some debates need to be considered. First, the concept cannot be separated into a simple dichotomy between open and closed approaches. Trott and Hartmann (2009) 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. Some studies have begun to identify different types of openness (Lichtenthaler, 2008; Dahlander and Gann, 2010). For example, Dahlander and Gann (2010) 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. Second, Chesbrough et al. (2006) proposed that the open innovation process can be divided into inbound and outbound innovation process. Inbound innovation process refers to explore and acquire external knowledge for internal use, while outbound innovation process refers to exploit internal knowledge for external use. Accordingly, this view provided opportunities to future research to further investigate the question of how a firm develop essential capabilities and/or adopt appropriate strategies/ practices in the outside-in and inside-out perspectives of open innovation process (e.g. Lichtenthaler and Lichtenthaler, 2009; Dalander and Gann, 2010; Bianchi et al., 2011).

Third, the open innovation approach proposes that valuable resources/knowledge cannot create value if they are locked within a firm, which means that valuable resources/knowledge from different companies should be combined in order to create value. However, the question of how a firm makes the valuable knowledge/resources flow freely between firms should be considered, because these kinds of important knowledge/resources do not automatically flow between firms and further make this knowledge flow to the appropriate departments and staff within focal firms. Previous studies suggest that firms need to develop in-source mechanisms for knowledge transfer between firms and within a firm to access and assimilate valuable resources and facilitate an open innovation process (Vanhaverbeke, et al., 2007; Dalander and Gann, 2010). This is because these mechanisms can be seen as the architecture within which individuals acquire, assimilate and further exploit the related knowledge between partner firms and within a firm, tacit knowledge in particular. However, there is less empirical evidence to investigate this context in the open innovation process, particularly in the design of intra-organizational knowledge transfer mechanisms to support open innovation activities.

Intra-organizational knowledge transfer mechanism
Previous studies argued that different communication mechanisms can be characterized as high or low degree of information richness (Daft et al., 1987; Sheer and Chen, 2004). They proposed that the degree of information richness depended on the level of attributes of a communication mechanism, including its feedback capability, language variety, availability of multiple cues (e.g. voice inflection, words, and graphic symbols) and personal focus (e.g. emotion and feeling). When a mechanism has more of these attributes, it can be identified as higher in information richness and having greater capacity to transfer knowledge. For example, face-to-face meeting is considered as the highest degree of information richness mechanism. It allows the mutual and rapid feedback, simultaneous communication of multiple cues, and high variety language which facilitates shared meaning among individuals.

In addition, previous studies mainly focused on the question of which mechanism (high or low information richness) are effective under different degrees of task ambiguity (Daft et al., 1987; Sheer and Chen, 2004; Gorovaia and Windsperger, 2010). A higher degree of task ambiguity may lead to misinterpretation and recurrent discussion to clarify the communication content. Thus, if the mechanism for knowledge transfer has a relatively higher degree of information richness (e.g. meetings, training and telephone calls), it will be capable of handling a higher level of task ambiguity. The lower degree of information richness of knowledge transfer mechanism (e.g. manuals, reports and databases) can be used for effectively transferring knowledge with lower degrees of task ambiguity. Previous studies also found that firms adopted cross-functional meetings and face-to-face and telephone conferences by members of cross-functional projects and small peer-to-peer group discussions within for the purpose of routing knowledge to appropriate departments and staff and completing the organizational task (Mante and Sydow, 2007; Hale and Tidd, 2009). Moreover, Gorovaia and Windsperger (2010) used the concept of information richness to operationalize the capacity of knowledge transfer. They found that franchisor used a higher degree of information richness mechanism for transferring knowledge (e.g. training, meetings, store visits) if the system-specific knowledge is more tacit. A lower degree of information richness mechanism for transferring knowledge (e.g. email, manual) would be adopted if the system-specific knowledge is more explicit.

RESEARCH DESIGN AND METHOD

This paper focuses on the question of how a firm uses different types of knowledge transfer mechanisms within its firm to contribute to the selected service developments. This research uses a case study design, which facilitates an empirical inquiry into a contemporary phenomenon in Taiwan, drawing on empirical evidence from four convenience store chains (i.e. Company E, F, H, and O).

Study population and unit of analysis

The study population of this research includes the Taiwanese convenience store chains involved in the selected service development. The chosen four convenience store chains (including Company E, Company F, Company H, and Company O) together control 95.51% of the market in Taiwan. In order to operate business in such a highly competitive environment, convenience store chains often break the existing boundaries by establishing cooperative relationships with other industries in order to develop new services/products to meet the new needs from consumers and increase turnover. To save development time and cost, the head office of a convenience store chain has to cooperate with external companies, such as IT system suppliers and logistics companies offering essential resources/knowledge to contribute new service developments. For example, convenience store chains cooperate across industries to develop new services (e.g. online shopping with pick-up at store service and multiple media kiosk service) hoping thereby to increase turnover and increase visits consumers, who already use their existing advantages (24-hour service, high density of store

spread, robust information systems and professional distribution systems). Moreover, the unit of analysis is an important component of case study design because it directly relates to what the case is (Yin, 2003). The unit of analysis of this research is the new service development project. Two types of e-commerce services (i.e. online shopping with pick-up at store service and the multiple media kiosk service) in Taiwanese convenience store industry were selected.

Data collection and analysis

Two methods of data collection would be used in this proposed research: documentation and semi-structure interview. This documentation can be collected from periodicals, books, magazines, newspapers, research reports published by research institutes, annual reports from case companies' websites. According to the shortcoming of documentation, such as retrievability, biased selectivity, reporting bias and an access problem, semi-structured interview will be adopted in the data collection process. It allows two-way communication and the flexibility to probe for details as well as gaining a range of insights on research issues. Semi-structured interviews were conducted with project managers and the section staff of the convenience stores in order to fully understand the development process of the services in question and increase the creditability of the present research. In total, this research conducted interviews with 16 interviewees. 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 to guide the initial data analysis in this enquiry. (Gibbs, 2008). The author draw on the existing literature and research questions to create codes and to identify key thematic ideas for developing thematic framework. Moreover, cross-case synthesis was chosen as the analytical technique to summarize the findings from the individual cases and to identify the similarities and differences between the selected service developments which are created by different convenience store chains.

RESEARCH FINDINGS

The present study found that the demand for the two selected service developments was proposed by the marketing staff of the case companies as a matter of market (consumer) demand. The marketing staff collect the related information from different sources (e.g. the industrial development experience of a foreign country, competitors and an internal analysis of consumers' behaviour) and create new business plans. In particular, case companies established IT system to analyze consumers' behaviour in order to understand consumers' potential demands and satisfy them. Moreover, the present study found that case companies recurrent use higher degree of information richness mechanisms (i.e. formal meeting and informal peer-to-peer discussion) to clarify different functional requirements and tasks and to assess and adjust possible solutions until a service is formally launched in the stores. This is because the members of functional staff have not fully realized what kinds of resources and knowledge must be acquired to contribute to the development of new services. The functional staff must gather greater information from other functional staff (e.g. the members of the IT

system, finance and store operation) and external companies in order to initially clarify the development requirements, evaluate the essential resources required and assess potential problems through formal meetings at different levels before deciding to develop a new service. Senior managers would be involved in cross-functional meetings to discuss possible development plans with different department managers and to assess the investment of essential resources in this regard. After a decision has been made, the staff of different departments (e.g. marketing, IT system, finance, store operation...etc) attended a project meeting with senior managers to transfer different areas of domain knowledge to different functional staff, to coordinate different functional tasks, and to continuously adjust the plans for service operation procedures in the development stage until the service is launched at the stores. Then project workers told their departments about the development tasks and organized staff from their departments to perform the functional tasks and identify the essential resources required from external companies. Between project meetings, different functional staff also held telephone and face-to-face discussions to share relevant knowledge, to identify development problems and to find possible solutions.

In particular, the intra-organizational mechanisms for transferring knowledge between the head office and each store of a case company are important, before a new service is launched at a store. The head office relies on the store staff to directly provide the new services for the consumers. The store staff must therefore fully understand the service operation procedure or they cannot help the consumers. The store operation department of the case company translates the operation procedure of the new service into formal documentation (i.e. internal announcement and operation manual), a lower degree of information richness mechanism for transferring knowledge, to quickly inform each convenience store about the new service project and teach the store staff about it. In addition, the head office also uses complementary training by the supervisors (a higher degree of information richness mechanism for transferring knowledge) to empirically teach and confirm that store staff fully understand the standard operation procedure of the new service and can operate it accurately. The supervisor is informed and trained in the operation procedure of the new service so as to pass on the knowledge to the store staff. This present study has further clarified that case companies used lower degree of information richness mechanisms (i.e. internal announcement and operation manual) for transferring knowledge to quickly tell store staff how to operate the new service and provide it to the consumers. In addition, case companies also used a higher degree of information richness mechanism for transferring knowledge (training by supervisor) to train staff in person and confirm that each store's staff could operate new service accurately, even though an operation manual had already been issued. Multiple mechanisms for transferring knowledge are used between franchisor and franchisees in the process of new service development.

CONCLUSIONS AND MANAGERIAL IMPLICATIONS

This present study found that the demand for the two selected service developments was proposed by the marketing staff of each convenience store chain as a matter of market (consumer) demand. According to previous studies, the demand to develop new services often has a market-pull orientation (Nijssen et al., 2006; Fasnacht, 2009). The members of the marketing staff collect the related information, create new business plans and then informally discuss their ideas with different department. Through the formal development process in making decisions, case companies used a higher degree of information richness mechanism for transferring knowledge (regular meetings at different levels) to discuss new project requirements and to assess potential problems within a department and across departments Then a project meeting was set up, involving the staff of different departments and their senior managers to discuss different functional requirements, to coordinate different functional tasks with different departments and external companies and to modify possible solutions during the development stage.

In particular, before a new service is launched at stores, the intra-organizational mechanisms for transferring knowledge between the head office and each store of a case company are important in this sector. Previous studies have argued that the choice of different degree of information richness mechanisms can be determined by the extent to which knowledge is (tacit or explicit) between franchisor and franchisees (Gorovaia and Windsperger, 2010). The empirical finding shows that multiple mechanisms for transferring knowledge are used between the head office of a case company and each convenience store before the launch of the new service launch at all the stores. In the present research, case companies used a lower degree of information richness mechanism for transferring knowledge (e.g. internal announcements and an operation manual) to quickly inform store staff and correspondingly adopted a higher degree of information richness mechanism for transferring knowledge (training by supervisors) to empirically teach store staff and confirm that they could operate the new service accurately.

In conclusion, the present research used the concept of information richness to operationalize the capacity of knowledge transfer. Thus it offered a better understanding of the adoption of different degree of information richness mechanisms for knowledge transfer within case companies in different stages of new service development. The present research also provided a better insight into the design of intra-organizational routines for developing new services in franchising. The design of intra-organizational routines for developing new services can be used to confirm that knowledge is flowing to the appropriate departments, teams and individuals.

Moreover, the present research offers some managerial insights. Firms could adopt a cross-functional project meeting and/or regular meetings at different levels within a department (i.e. higher degree of information richness mechanisms) in the early stages of developing new

services in order to clarify the requirements of different sections/departments, transfer essential information to appropriate individuals, which may contribute to the development effectiveness. After a new service is developed and the solution has been codified and stored in some way, such as training program and operation manual, firms could directly use internal announcement and operation manual (i.e. lower degree of information richness mechanisms) to quick inform each store and combined training/ supervising programs (i.e. higher degree of information richness mechanism) to ensure accurate service operation provided by store staff.

REFERENCES

1. Bianchi, M., Cavaliere, A., Chiaroni, D., Frattini, F., and Chiesa, V. (2011), "Organisational modes for open innovation in the bio-pharmaceutical industry: an exploratory analysis", Technovation,   Vol. 31 No.1, pp.22-33.
2. Chesbrough, H. (2003), Open Innovation: The new imperative for creating and profiting from technology. Boston: Harvard Business School Press.
3. Chesbrough, H. (2006), Open Business Models: How to Thrive in the New Innovation Landscape. Cambridge, MA: Harvard Business School Publishing.
4. Daft, R. L., Lengel, R. H., and Trevino, L. K. (1987), "Message equivocality, media selection, and manager performance: implications for information systems", MIS Quarterly, Vol.11 No. 3, pp. 355-366.
5. Dahlander, L., and Gann, D. (2010), " How Open is Innovation?" Research Policy, Vol.39 No.6, pp. 699-709.
6. Fasnacht, D. (2009), Open Innovation in the Financial Services. Springer-Verlag, Berlin Heidelberg.
7. Foss, N.J., Laursen, K. and Pedersen, T. (2011), "Linking Customer Interaction and Innovation: The Mediating Role of New Organizational Practices", Organization Science, Vol. 22 No.4, pp. 980-999.
8. Gibbs, G (2008), Analyzing qualitative data, London, Sage Publication.
9. Gorovaia, N., and Windsperger, J. (2010), "The use of knowledge transfer mechanisms in franchising", Knowledge and Process Management, Vol. 17 No.1, pp. 12-21.
10. Hale, M. and Tidd, J. (2009), "The practice of routines and representations in design and development", Industrial and Corporate Change, Vol.18 No.4, pp. 551-574.
11. Lichtenthaler, U. (2008), "Open innovation in practice: An analysis of strategic approaches to technology transactions",   IEEE Transactions of Engineering Management, Vol.55 No.1, pp.148-157.
12. Lichtenthaler, U., and Lichtenthaler, E. (2009), "A capability-based framework for open innovation: complementing absorptive capacity", Journal of Management Studies, Vol. 46 No.8, pp. 1315-1338.
13. Mante, A. and Sydow, J. (2007)," Inter-organizational Routines: Coordinating R&D Practices in International Alliances", in International Conference on Organizational

Routines: Empirical Research and Conceptual Foundations 2007, Strasbourg, France, May 25–26.

14. Sheer, V. C., and Chen, L. (2004), "Improving media richness theory: a study of interaction goals, message valence, and task complexity in manager-subordinate communication", Management Communication Quarterly, Vol.11 No.1, pp. 76-93.

15. Trott, P., and Hartmann, D. (2009). Why open innovation is old wine in new bottles. International Journal of Innovation Management, 13(4), 715-736.

16. Van Haverbeke, W., Cloodt, M., and Van de Vrande, V. (2007)," Connecting absorptive capacity and open innovation", Centre for Advanced Study (CAS) workshop on Innovation in firms, Asker, Norway, October 30- November 1.

17. West, J., and Gallagher, S. (2006), "Challenges of open innovation: the paradox of firm investment in open-source software", R&D Management, Vol.36 No.3, pp. 319-331.

18. Yin, R.K. (2003), Case study research: Design and methods. (3rd ed.). CA: Sage: Thousand Oaks.

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AN ANALYSIS OF PRACTICAL BUSINESS MODEL FOR PRODUCT-SERVICE SYSTEM

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ABSTRACT

Within the context of recent business environments featuring more customer & client centric business, energy & resource efficient business, and the new innovative convergence between manufacturing and services, the "manufacturing" and "service" sectors are no longer separate from each other. Over the last two decades, scholars have studied the subjects related to the convergence of manufacturing and service business. Thanks to this effort, we have better understanding of the new concepts such as Product-Service System (PSS), Servitization, Productization, and Service Science Management and Engineering (SSME), Service Design etc. Each term has slightly different meaning; the core objective is to make businesses profitable, competitive, and innovative.

Although prior studies can give us good motivation and useful research foundations from which to investigate innovative business practices in the new era, it is arguably difficult for companies to apply the findings of these studies to current business practices. This is due to the insufficient clarification of key concepts, the lack of differentiation from general pure services, lack of case research or data analysis with fundamental understanding, and the lack of useful business models with the core PSS characteristics. Thus, this study aims to explain key characteristics of PSS and analyze the strategic benefits and potential of PSS. This research was conducted with the help of over 200 PSS like business cases from all over the world. To conclude, we try to propose a sustainable, real world PSS business model.

INTRODUCTION

We have been facing new types of business situations that come from the rise of emerging markets, the global financial crisis, the lack of available resources, environmental pollution, and the convergence of business with information technology. In particular, information technology has been a big influence and its potential is increasing. It is clear that all of these factors will be strong motivators and part of the new normal for all businesses.

Rifkin (2011) pointed out that a third industrial revolution is imminent, and commented on environmental issues and resource scarcity in his book. His claims propose that it is necessary for businesses to develop new perspectives about resources and the environment. Kaletsky (2010) proposed a model he called Capitalism 4.0, in which the role of government, macro economy, and financial environment may need to change to reflect the new era properly in his book. Kotler (2010) suggested a model he called "Market 3.0," in which the customers will be smarter, and more emotional than before. Additionally, they are expecting that they will satisfy the desires of the soul rather than physical desires. Market 3.0 can be summarized in a few expressions such as "Customer's Participation, Paradox of Globalization, and Creative Market & Society". Hence, in this new era, governments and societies have tried to build creative economies and societies in order to achieve sustainability. Along with this trend, manufacturing businesses are seeking to diversify their businesses by including services, and service businesses are transforming into information- and knowledge-oriented businesses. Under this phenomenon, Product-Service System (PSS), which is one of the academic efforts, has shown a meaningful conceptual framework for the convergence of products and services that correspond to the trend of the new era.

Many companies have tried to adjust to this phenomenon by transforming their businesses. However, they have been facing practical difficulties in the early stages of transformation or starting their new business. It is necessary for them to be given practical concepts and guides from the perspective of an individual company (Barquet, 2013). Examples of providers of this service are CxO and Top management who design businesses and make important decisions that require methodologies and business models in order to organize systematically.

This paper proposes practical business models based on data analysis of many PSS-related business cases. Among PSS study areas, few studies have attempted to construct a PSS business model (Vijaykumar, 2012). The previous research studies that have focused on business models are limited to a few specific business areas and have purely conceptual approaches. However, this paper will suggest practical outcomes with common characteristics, based on cases of diverse business industries and approaches that will explain how the model can be applied to real world businesses.

In order to have a more logical basis, more than 200 types of practical business model have been collected from more than 100 books & papers indirectly and 1000 company businesses have been reviewed directly in Korea. Those data are analyzed by diverse means in order to find insights. With this analysis, the identified key aspects are used for building new type of generic PSS business model and developing guidelines of how to apply them to real world businesses.

LITERATURE REVIEW

This paper aims to study a practical methodology of a product–service system that enables the convergence of products and service in all businesses. The perspective of this paper is little different from previous research studies into PSS, which means that manufacture is running a service business. In this paper, PSS is developed as a bigger and wider concept in order to include more innovative ideas.

Generally, developed countries have a more service-intensive industry structure, and the industrial sector of developing countries is relatively more product-intensive. Therefore, service businesses are considered a symbol of advancement or key drivers of the economy (Park, 2012). However, despite the fact that service businesses are undeniably important, this paper claims that the separation of business types cannot provide enough innovation momentum in either the current or the upcoming era. It is imperative to consider the convergence of products and services in all businesses.

For the concept of a convergence system, it is necessary to research its components, activities, supports, conceptual boundaries, business model, etc. Therefore, it is therefore imperative to review how previous studies regarded service, servitization, productization, and product-service systems. This paper will participate in the progression of PSS studies by extending the previous research and suggesting different perspectives for practical applications.

Service
Generally, service is an intangible activity with some auxiliaries. It involves a certain level of interaction with customers in order to solve their issues (Fitzsimmons, 2012). Previously, service was just free labor that assisted the selling of a product, but service has gradually become an important means through which to deliver value (Park, 2012). From the perspective of industries and businesses, most developed countries and even some developing counties have a higher rate of employment in their service industry than in their manufacturing industry (Ryu, 2009). It is important to specify the characteristics of a service job. A clear understanding of the characteristics of services and products is the starting point of PSS innovation: First, a service is invisible. Second, a service is concurrent to producing and consuming products. Third, service is extinctive, as a service cannot have stock. Fourth, service is always different even though it is the same service being offered. Lastly, service has the limitation of time and space (Park, 2012). Vijaykumar (2012) described two perspectives for service: One was a typical perspective, another was the broader concept. The typical approach focused on maintaining of the functionality of a product. The broader approach outlined how service is an important method for realizing customer value. For the attributes of a service approach, a typical service has several attributes including invisibility, extinction, and concurrency. However, the broader approach of a service doesn't yet have

differentiated attributes.

Table 1. Definition of Service [Ryu (2009), Vijaykumar et al. (2012)]

Author	Definition
Levitt(1972)	It can be found in all industry. It is the matter of many or less.
Berry & Parasuraman(1991)	There is no clear boundary which separate product and service. There is also no way to classify those.
Sakao and Shimomura (2007); Sakao et al. (2009)	It is a activity which change it's status corresponding to customer's demand. A contents or channel are one of key means.
Maussang et al. (2009)	A service has a role which makes system flexible.
Alonso-Rasgado et al. (2004)	A service makes provider's value delivery available.

Product-Service System

In the literal sense, PSS is a system that consists of product and service. Goedkoop (1999) defined PSS as follows: "Product Service system (PS system) is a marketable set of products and services capable of jointly fulfilling a user's need." Although Goedkoop (1999) defined PSS as an innovation system for customers, researchers (particularly those in Europe) have recently tended to focus on the perspective of manufacturer service capabilities and ecological dematerialization (Beuren et al., 2013). However, it is also necessary to revise the practical concept of PSS while improving its original initiative. This is one of the motivations of this paper.

Table 2. Definition of PSS [Baines et al. (2007), Beuren et al. (2013)]

Author (date)	Definition
Maxwell et al. (2006); Baines et al. (2007)	"PSS goes beyond this view and, instead, aims at sustainability by seeking a balance between environmental, economic, and social concerns"
Kang and Wimmer (2008)	"In general, products are developed to satisfy consumer demand and are customizable to include services. The example of a car sharing system, as mentioned earlier, is aimed at renting services to satisfy customers"
Yang et al. (2009)	"PSS is a competitive opportunity, which is important for how it is able to alter consumption standards. In other words, this subject aims to improve both competitiveness and the pursuit of balance between social, economic and environmental issues"
Manzini and Vezzoli (2003)	"PSS is a strategic design intended to integrate a system of products, services and communication based on new forms of organization, role reconfiguration, customers and other stakeholders"

Author (date)	Definition
Manzini and Vezzoli (2003)	"People acquire products, and sustainable solutions in the project design phase are needed for them to accept the PSS"
Vogtländer et al. (2008)	"The main concerns for producing a more sustainable product are planning for its durability and including services to reduce the amount of materials that go into the product"
Li et al. (2010)	"An important concept in industrial ecology, dematerialization has permeated into all phases of product life cycle"
Kestemont and Kerkhove (2010)	"in companies reducing the amount of natural resources, observers see a trend towards developing more efficient products and services"
Cleary (2010)	"Seeking to continuously improve customer satisfaction as well as sustainable development from the reuse of products"
Baines et al. (2007)	"the dematerialization of products has been discussed in the literature and also has been used as a goal for the PSS"
Kestemont and Kerkhove (2010)	"The main objective of dematerialization is to improve the well-being of society through more efficient and sustainable development"

As specified in <Table 2>, there are many research studies that deliver concepts and understanding with case analyses or conceptual ideas. Recently, with the help of engineering and system design research, many research studies have also focused on service design. However, those approaches tend to underestimate the importance of PSS as an innovative business model. In order to develop specific service designs, it is imperative to have a well-defined and described business model or a business strategy that reflects the business characteristics of PSS.

It is generally accepted that the manufacturing business has been separated from service business so far. Even inside any single business, products or services they produce tend to be isolated from one another. It is sure that this kind of approach has given us some sort of advantage such as mass production for efficiency, specializing for effectiveness. As there are two sides to everything, it also has disadvantages, which include collective consideration and lost potential synergy between any two objects (Vandermerwe and Rara, 1988). Without separation, all industries would need to have capable   products and services. This is another hypothetical claim of this paper.

Servitization

Similar to PSS, other research topics such as "servitization" and "productization" should be considered. Vandermerwe (1988) argued that it is necessary for all industries to have the capability to see their business from a convergent perspective, not separately. He called this "servitization." Lightfoot (2013) proposed that the research of servitization has five distinctive areas: Services marketing, service management, operation management, product-

service system, and service science. The goals of servitization are the "differentiation of product & service, competitive strategy, customer value, customer relationships, product-service configuration". Ducq (2012) suggested that servitization means service in the manufacturing business. This concept of servitization is similar to that in PSS.

Table 3. Definition about Servitization [Ryu (2009)]

Author (date)	Definition
Neely (2007)	A servitization is to provide product, service, knowledge, support and self-service in all together.
Robinson (2002)	It means that it is evolving to the step where it can't be seperated while it is fused completey even though it was just supplementary one in the past.
Oliva and Kallenberg (2003)	The recognition for service in manufacture is changing from supportive activity to individual value for sale.
Baines (2007)	As one of sub system of servitization, the important of product-service system is getting increased since the late of 1990 in northern Europe.

This paper proposes that PSS is hypothetically more suitable for consideration as an overall system that contains all sub components and activities. Otherwise, servitization & productization need to be considered as smaller key activities within PSS. This, again, is a very different perspective compared to previous research.

Productization

We can literally presume that the opposite of servitization is productization. AlajoutsijaÈrvi (2000) proposed that service issues in the software industry could be solved with the concept of "productization." Chattopadhyay (2012) mentions that productization can reduce the volatility of services, maximize efficiency of services, and help visualize services, even though these are generally accepted norms in the service industry. Jaakkola (2011) pointed out that productization means the standardization of service, the actualization of service, and the improving the structured processes. Aapaoja (2012) argued that productization has advantages that can clearly define value for customers, increase customer loyalty, and improve service quality. However, few research studies clarify the relationship between servitization and productization under PSS. This paper proposes the hypothesis that productization is the opposite of servitization, another key activity in PSS.

PSS Business Model

Vijaykumar (2012) explained that the research into business models for PSS is in its relative infancy. Moreover, there are fewer research studies about business models based on the analyzed data.

Figure 1. Research Categories in the PSS domain [Vijaykumar et al. (2012)]

Barquet (2013) tried to research PSS business models; he used a business model canvas that was suggested by Osterwalder (2011). With this model as a base, he tried to explain the most common taxonomy for PSS.

Figure 2. Business Model Canvas [Barquet et al. (2013), Osterwalder (2011)]

Kindström (2010) based his research into the key aspects of the PSS business model on seven manufacturing company cases. His business model has six key elements: Value proposition, revenue mechanisms, value chain, value network, competitive strategy, and target market.

PSS is a system for the two most common business components (product and service). Through this system, real world businesses are trying to deliver special value to their customers. Hence, this paper suggests that a hypothetical PSS business will have a special PSS business model that includes those two common businesses components (product and service).

METHODOLOGY

The paper aims to propose practical PSS business type and model that allows new perspectives of PSS. The methodology used in this paper consists of four steps

Figure 3. Approach of Methodology

First, this paper tried to collect enough data for analysis. As such, 219 business cases were collected from more than 200 articles, papers, and books. Additionally, the sales ranking of the top 1000 companies in Korea were investigated in order to include more cases; this top 1000 data originated from the Bank of Korea. Then, each data point's official announcements, homepages, and documents such as annual financial reports were individually reviewed. In addition to the collected data, more than 200 qualitative findings were gathered. These findings were used for developing a generic PSS business model and supporting concepts.

Figure 4. Source Data for analysis (219 business cases)

The second step was to develop common PSS business types. The 219 business cases were categorized into 39 business types by particular common characteristics. In succession to it, the 39 types were positioned into the four stages of customer behavior. In addition, the six types of common customer needs that show the characteristics of PSS businesses well are developed for the 219 businesses and the 39 types of PSS business

The third step was to analyze the original business cases and the 39 PSS business types with diverse perspectives. At this time, several taxonomies were mainly used to get insights, as shown in <Table 4>. Because of this analysis, several taxonomies were developed through in-depth analysis, as shown in <Table 5>

Table 4. Taxonomy List used for PSS Analysis

Taxonomy	Description
Industry	International Standard Industrial Classification of All Economic Activities, Rev.4 [Source:http://unstats.un.org]
Business Relationship	B2B, B2C, B2G, C2C, G2C, G2G (Business, Customer, Government)
Time to Business	Before 1900, 1900~1960, 1960~1990, 1990~2000, 2000~2010, 2010~Present
Partnering vs. Solitary	Partnership vs. Solitary
PSS Service Types	Product Oriented Service, Use Oriented Service, Result Oriented Service – [Tukker(2004)]

Table 5. Taxonomy List developed by PSS Analysis

Taxonomy	Description
PSS Key Activities	Servitization vs. Productization
Business Stage	Pre-sale, On-sale, In-use, Post-sale
PSS Business Types	<Table 6> 39 PSS Business Types in 4 Categories
Customer Expectation	Economical, Convenient, Customizing, Informative, Humanity, Participation
PESTLE	Political, Economic, Social, Technology, Legal, Environment

Finally, those findings resulted in a PSS business model and components of PSS business model, plus a high level approach for practical application.

Figure 5. Overall Methodology Framework

RESEARCH ANALYSIS

In order to analyze the various aspects of PSS, several descriptive statistics based on taxonomy are used. The reason for this is the limitation of the data in which not the all data has been developed in a controlled environment and under the same conditions. Hence, in order to maximize the validity of analysis and minimize argument, this method is used. Moreover, if the volume of the data is enough, some levels of its tendencies will be meaningful.

Descriptive Analysis

<Figure 6> depicts how many PSS-like businesses there have been in each period. For example, one business case was developed in ancient Greece in AD100. In East Asia, several PSS business can be identified in Korea and Japan. This occurred at 500–600 years ago and 200–300 years ago, respectively. <Figure 6> shows that PSS business practices have been around for a long time. This means that there has always been a general demand for PSS businesses. Each time interval in <Figure 6> denotes an era such as the era of the industrial revolution, the era of mass production, the era of high economic growth, the era of the information revolution, the era of the Internet, and now. As shown in <Figure 6>, it is deducible that information and communication technology have had a great influence on PSS businesses from 1990–today. It is easily identified that most average PSS businesses could not exist without Information & Communication Technology.

<Figure 7> represents which industries have more PSS-based businesses. Even though the manufacturing and service industry are the majorities, because both have many sub categories, there was no unique difference found between the industries. Hence, most industries have a similar level of potential for PSS business practices.

Figure 6. Time to business

Figure 7. Industry

<Figure 8> shows which types of business relation are popular in PSS. Although B2C business is the majority, B2B also has many cases and a considerable amount of B2C cases can be seen as B2B. One insight is that B2B business is becoming similar to B2C due to PSS business practices. Although there is no classification for the government side in this paper, several government services are applicable with the PSS model.

<Figure 9> has an important implication. Three quarters of the business cases are cases of servitization. However, one quarter of the business cases are related to productization, which means that services and intangible assets such as data, information, knowledge, and

experience can be meaningful products. These can then be given as a service to customers.

Moreover, servitization and productization are reclusively repeated in several cases. For example, private institutions generally deliver knowledge or experience as a service. This service can be packaged as a product such as a DVD or CD. Recently, this content has been provided through the Internet as a service. In this business scenario, we can find that product and service innovation can be occur continually if some appropriate technology from within an appropriate business context is developed and an ecosystem or business context is ready to take advantage of it. This paper identified 15 recursive PSS business cases.

Many PSS and servitization research has been related to manufacturing. For instance, Baines (2013) recently published a book about servitization and emphasized the importance of his advanced service for manufacturers. However, this kind of approach reduces the potential of PSS; it is necessary to maintain a wider approach that can make full use of the potential of PSS.

Figure 8. Type of Business Relationship   **Figure 9.** Servitization vs. Productization

In <Figure 10>, one of the most popular taxonomies for PSS that was proposed by Tukker (2004) is used. The majority of this classification is a Product Oriented Service (POS). Although recent PSS research has usually focused on Use Oriented Service (UOS) or Result Oriented Service (ROS), POS has stronger potential and more practical opportunities for implementation. The previous POS was just positioned as a general support service or equivalent. However, recent POSs have been deeply involved in extending the functionality of products in diverse ways.

The PSS business is one of convergence. Because of this generic characteristic, PSS businesses have previously been generally based on partnerships. However, after the servitization of manufacturing has had more recent attention, solitary PSS businesses have

become popular in the market as shown in <Figure 11>. However, there is a need to consider this phenomenon carefully. Although the number of solitary PSS businesses is increasing, there is a high possibility that solitary businesses are not purely solitary. From another servitization perspective, a partner's capabilities tend to be fused to manufacturing or another service provider. If we consider the complexity of modern industries or society, it is natural to consider partnerships for all situations.

Product Oriented	Result Oriented	Use Oriented
143	27	49

Partnership based	Solitary based
61	158

Figure 10. Taxonomy by Tukker (2004)   **Figure 11.** Partnership vs. Solitary

From the perspective of a manufacturing company, the manufacturing itself is losing its value relatively in the business value chain, due to the intensification of competition, rapid product lifecycles, commoditization, and etc. (Park, 2013). The "Smile Curve" or "Well Curve" is one piece of research related to this phenomenon. This concept was proposed by Shih (2001), who is the founder of Acer, which is an IT company in Taiwan. As shown in <Figure 14>, the value of the manufacturing area is relatively smaller than other areas such as R&D, Marketing, Sales, etc. Although this concept is based on the IT industry, it is certain that this kind of situation is not unique to the IT industry (Park, 2013). Because the value of each business is related to a customer's individual concerns, the opposite side of the company value chain can be mapped over the customer's behavior lifecycle.

Figure 12. "Smile Curve" [Source: http://en.wikipedia.org/wiki/Smiling_curve]

From the perspective of consumer behavior, businesses need to care about the whole lifecycle of a consumer's consumption behavior in order to deliver business value (Lee, 2010). It is certain that most PSS business is related to how to give the consumers value, as shown in <Figure 13>. However, as mentioned in the introduction of this paper, modern business contexts are facing different situations, such as smarter consumers, consumer participation, recycling or efficient resource consuming, etc. In order to correspond properly to these, it is imperative to consider the whole life-cycle of consumer behavior. As another implication, the reason why the "In-Use" stage is the largest for PSS is that PSS businesses are based on deliverable core values. This is then commercially ready to be sold by fusing it with an appropriate service, in the case of servitization. If the service has a distinctive value, it can be productized recursively as a deliverable core value. This implies the basic approach for PSS that this paper proposes.

It is certain that all businesses are influenced by external factors such as political, economic, social, technological, legal, and environmental factors. The analysis of these factors is called PESTLE Analysis, which is a well-known tool for developing typical business strategies. Although the rest of the factors are also important and the environmental factor has been one of the key motivators for researching PSS, there are three primary factors in practical terms, which are the economic, technological, and social factors, as seen in <Figure 14>.

Figure 13. Consumer Behavior Stage

Figure 14. PESTLE

Finally, through descriptive analysis with other qualitative insights, this paper has developed a model of 39 common PSS business types. These types are categorized by consumer behavior stage.

The PSS is not itself manufacturing or a service. Therefore, it does not create any products or services; it is a dynamic system that increases the value of products and services. Therefore, PSS can be used in any industry, even governments. For an example, although Zipcar runs a car business, they don't make any cars, they are just improving the value of cars. Under PSS, it is important to find out how to improve value. To initiate a PSS business, it looks to find a keyword for the PSS business, such as total, expanding, or share.

Although 39 types are identified, this does not mean that these are fixed. This figure just comes from the 219 business cases, which means that there always can be other types. It will be highly related to the ecosystem, business context, market, and the customer's demands. In order to build the right PSS business model, the first job is to find right keyword that explains the relation between products, services, and the customer's needs. <Table 6> shows the 39 PSS business types which were developed from this implication.

Table 6. 39 PSS Business Types in 4 Categories

Category	Types	Description	# of Cases
Pre-Sale	ACKNOWLEDGE	proactive market positioning service	3
	INFORMATION	information providing service	3
	FACILITATE	facilitating service for trading & exchanging	8
	RELATIONSHIP	Relationship service	1
	PARTICIPATION	Participating service into business	2
	DEMONSTRATION	Sample, Demonstration, Test Products	1

Category	Types	Description	# of Cases
On-Sale	SHOPPING	Fun, safe, economical, convenient shopping service	8
	FINANCE	financial support for purchasing	2
	DELIVERY	delivery service	1
	INSTALL	installation & configuration service	3
In-Use	EXTEND	extending product or service functionality	6
	SHARE	sharing products (which have the concept of using)	18
	RENTAL	rent products (which have the concept of temporary possession)	23
	RESULT	final result producing service	10
	PROXY	proxy service for special function or activity	2
	ADVISORY	advisory, consulting service	12
	TOTAL	total solution service	16
	FREE	free or discount service for encouraging other business	3
	CUSTOMIZING	customizing service for personal needs	5
	CONTENTS	contents providing service for using product	8
	TRAINING	training or guide service for proper using	3
	MONITORING	monitoring or watching service for sustainability	4
	VIP	providing high quality service for better value	1
	EMOTION	satisfying human emotion	2
	REFILL	refill or recharging service	5
	GUARANTEE	maintain or guarantee service for sustainability	6
	CHANGE	physically changing(split, add, mix, and etc.) service	1
	TICKET	ticket issuing for right of use	17
	LESS_LIMIT	remove limitation of service such as time, location	8
	HAVE	allowing possession service tangibly	3
	SELF	enabling self-service through product changing or redesigning	7
	FUNCTION	replacing service with products	10
	SYMBOL	products including special value such as brand, conviction, belief	5
	CONVERGENCE	Integration or convergence including multiple products or services	1
Post-Sale	REMODELING	remodeling product or service	2
	TERMINATE	help for terminating product	1
	USED	exchanging used product	4
	BUY-BACK	buy-back for encouraging selling new product or service	1
	RECYCLE	recycling product into improved product	3

From another perspective, the PSS Business Type can be considered a result of the PSS function with two parameters. One is the characteristics or meaningful attributes of product or service. Another is the customer's needs.

PSS function (Characteristics of product and service, Customer's demand) = PSS Business Type

The characteristics of PSS can be highly varied for each respective business. But, it is possible to deduce a customer's needs through the reverse analysis of PSS business types. Hence, this paper proposes six PSS-specific customer's needs at the high level, as shown in <Table 7>.

Table 7. Customer's Needs specific to PSS

Taxnomy	Description
PSS Key Activities	Servitization vs. Productization
Business Stage	Pre-sale, On-sale, In-use, Post-sale
PSS Business Types	<Table 6> 39 PSS Business Types in 4 Categories
Customer Expectation	Economical, Convenient, Customizing, Informative, Humanity, Participation
PESTLE	Political, Economic, Social, Technology, Legal, Environment

It is meaningful how different these needs are compared to a typical customer's needs. As shown in <Table 7>, those needs are different from a typical customer's needs. The typical customer's needs are direct and positioned at a lower level in Maslow's hierarchy of needs. Therefore, these needs are usually satisfied by a typical product and service. Otherwise, PSS-specific needs are indirect and positioned at a higher level in Maslow's hierarchy of needs. This implies that PSS has another potential in business, which can be a way to satisfy customer's higher needs.

Key Findings

Finding 1. All businesses are PSS businesses.

For a certain perspective of PSS, all businesses are PSS businesses; all businesses have some level of service for value delivery, products for core value that satisfy the customers' needs. Even those that are pure service, have core values that are considered products, even if they are intangible such as money in a bank, medical knowledge for staff at a hospital. As mentioned before, the needs of PSS are different from typical needs. They can be applied to any product or service to improve value.

Finding 2. PSS is a convergence system.

PSS is not another replacement of a pure product or pure service. PSS is a convergent system that mainly consists of product and service. This system should encourage participation in value improvement in creative ways. With servitization and productization based on a base value that products and services can deliver, PSS makes customer's needs possible.

To encourage PSS business practices, it is imperative that unique technologies and methodologies are developed for each PSS. Any differentiated technology or methodology gives business advantages such as sustainability and profitability. For example, information technology is a core technology of most of PSS businesses.

Figure 15. PSS Technology and Methodology

Finding 3. PSS is a destructive innovation.

Based on reviewing PSS business cases, there is much evidence that shows that PSS is a good case of destructive innovation. Most PSS businesses have tried to change their business context, and so the rules of business. For example, Apple's iPhone was not just a phone, but a smart computing device. Therefore, the iPhone needs to the App Store service.

Finding 4. Service and product as key components; servitization and productization as key activities.

If we consider PSS as a system, this system needs players, components, activities, and boundaries. There are three key players: The customer, the partner, and myself. These players are deeply engaged with each other for the final solution. There are two key components, which are the product and the service, and there are two key activities, which are servitization and productization.

Finding 5. PSS is dynamic rather than static.

For PSS, the activities of servitization and productization are not fixed at just one time. It is reported that even successful PSS businesses need continuous efforts in innovation to go along with the situation of the business ecosystem. It is interesting to note that a PSS business model itself can be changed through the repetition of servitization and productization, so called "Recursive PSS". Any PSS business can be remodeled reclusively from its original PSS business model. Put simply, any product can be servitized and then the service can be productized again for a similar or different purpose.

Figure 16. Recursive PSS Innovation

Finding 6. Servitization as Value Delivery; Productization as Value Capturing.

Although the service industry and service businesses are getting more important than typical product businesses, both activities are equally important because we need to consider value delivery and value capture for all businesses. This is just a matter of finding the appropriate business model that can satisfy the customers' needs. Although there are more servitization business models than productization business models in data, if we consider that future markets will be more customer-centric, productization businesses will become more important than before. With the help of information technology, the concept and coverage of products is getting larger, to include such concepts as virtualized products.

Finding 7. PSS aims to find a total solution for customer experience.

As shown in <Table 8>, PSS tries to satisfy more customer needs. In order to do this, more solutions are needed. Hence, all PSS businesses head towards developing total solutions for the entire customer experience. In the market, the overall customer experience is becoming more important quite rapidly. This kind of trend cannot be solved with a typical product or service approach. Necessarily, PSS business model is highly demanded for many reasons, such as value expanding, differentiated business, and more profitable.

Finding 8. PSS is not limited to single product, single service, and single company.

This paper insists that PSS should not be only for manufacturing companies. Most successful PSS businesses in practice have a good partnering system with many partners and stakeholders. It is widely accepted that manufactures actively need to provide more services for customers, need to consider service-oriented businesses for differentiating their business, and need to have the capability to deliver services. Whether it is based on an individual

company or a partnership, it is just matter of business strategy.

Finding 9. The primary concern is the PSS business model or PSS business strategy.

In practice, PSS is still not well known in the industry. Although people have heard of terms such as PSS and Servitization, they cannot clearly differentiate between pure service and PSS, and for many of them, PSS is still a rental business. Because of this, there are fewer practical guides that can be applied to real world businesses. In practice, in order to be used widely, there should be many research studies about business models and strategies with best practice. It is certain that research for business models is an insufficient condition for PSS businesses. However, this must be the primary starting point if we are to consider typical business planning practices.

Finding 10. PSS business models diversify costs, revenue structures, and portfolios.

Under PSS, the revenue stream of a business can be diversified and enhanced. Generally, from a marketing perspective, most products and services try to focus on a specific market segment; this causes business rigidity. However, PSS can diversify a product or service's sales stream through the effort of servitization and productization. Otherwise, the complexity of the cost structure of PSS businesses may increase.

Generic PSS Business Model

In order to present a framework for a generic PSS business model, this paper proposes two design directions for PSS, based on the above findings. One is a vertical value actualization, which is relatively more related to the macro perspective. The other is horizontal value realization, which is relatively more related to the micro perspective.

The vertical process actualizes the opportunity of external changing into monetizing efforts. At the high level, this process consists of three major phases (Value opportunity, Value development, Value monetization). The Horizontal process realizes business opportunities to the customer's satisfaction. Therefore, ultimately, PSS aims to realize customer's satisfaction through dynamic business diversification.

As mentioned earlier, PSS is a dynamic system that corresponds to changes of the customers, market, and the ecosystem. Whenever a specific PSS business model is developed, these two design directions should first be considered before details can be discussed.

Figure 17. Two Direction and Base Framework for PSS

This paper uses Osterwalder (2010)'s Business Model Canvas as a tool for describing a generic PSS business model. Barquet (2013) also used this model for his paper to describe POS, UOS, and ROS. This paper uses this is because it is a well-known framework, easy to understand, and its lessons can be easily applied to any business.

With the analysis and insight that this paper has suggested, the base framework is enhanced as shown in <Figure 17>.

For the area of Value Opportunity, this paper put the result regarding to PESTLE analysis. In the analysis, Social, Technological, and Economic factors were the major factors in PSS business development. Hence, this paper suggested four factors, which are Ecosystem Trend, Market Trend, Technology Innovation, and Policy & Regulation Changing.

For the area of Value Monetization, due to the characteristics of PSS businesses, the cost structures are complex and the revenue streams are variable. As shown in <Figure 18>, costs can occur on the side of customer. Similarly, revenues can occur in any area of the value chain.

The value processing area consists of six key steps: The first represents source key partners who provide source values such as source materials or source service units. The source partner may also have a PSS business model. In order to deliver service-oriented value, their business processes can be placed into our business processes deeply, like our own process.

The second parts are the key resources, key activities, and source partner support. With these, source products and source service units can be developed.

The third part shows the product value proposition. In this step, the actual merchandise is prepared. The typical manufacturer will generally focus on this step. The key point in this step is that the product is integrated into the service area rather than positioned as a single product. Without this, servitization is not well realized because pure products are ready for PSS-specific demands. For example, in the case of the "Zipcar," it is necessary to build additional devices or prepare management systems for car sharing. It is impossible to deliver service businesses with just a car that has been made by car manufacturer. In this time, servitization technology and methodology is needed.

The fourth part is that of the service value proposition. As described above, services take care of the value delivery in which all the core values, such as the product, are delivered within the service. These are not pure services, but the servitization of products. From a simple delivery to a complex total service, all service activities are developed with two factors in mind: Servitization technology and methodology. One is the characteristics of the core products; the other is the characteristics of the customer's needs. The technology and methodology of servitization depend highly on these.

Another key finding is a reverse activity, so called "productization." As mentioned above, servitization and productization are not just one-time activities in business. These activities can be repeated ad infinitum. In this paper, there are six types of productization model. Generally, in this step, two productization types are consistently available to any business. One is minor productization with feedback that can help improve the product; the other is major productization, which produces an entirely new product that incorporates identified valuable services.

The service activities can be extended to a service partner or even into the customers' area. Similar to a source partner's efforts, co-value creation is one of the more advanced servitization activities. One good example is an IT system management outsourcing business such as IBM. The service providers are deeply involved in the customer's business area in order to leverage the service provider's competency systematically rather than just buy a simple service.

The fifth part is the key partnership for service; the servitization activities can be delivered by external partners. The traditional service such as delivery provides is usually performed by an external partner, and like a source partner, collaboration and extended convergence efforts with these partners is usually advisable.

The sixth part is related to the customer. Generally, the customer area is solely an area of consumption. However, due to the recent innovations in computers and the Internet, the customer area is getting more important for adding final value. Customers are eager to provide feedback, participate in the value chain, and distribute information.

Figure 18. PSS Business Model Framework

<Figure 19> depicts how the PSS Business Type is mapped over the PSS Business Model. With all the consideration that has been proposed in this paper, in order to build a differentiated business model, the following questions should be answered in order to run a real world business.

- What type of business opportunities are identified?
- What type of characteristics of core products can be described?
- What type of customer's needs or participation are identified?
- What type of servitization (or productization) opportunities are discovered?
- What type of servitization (or productization) technologies and methodologies are developed?
- What type of partnerships can be used or leveraged?
- What type of cost and revenue structures are developed?

Figure 19. Generic relations of the PSS Business Model and the PSS Business Type

CONCLUSION

In the PSS research area, the research studies that have performed quantitative and practical research are uncommon. One of the reasons is that it is difficult to develop meaningful data and hard to get practical data. The efforts of this paper are some of the first to take on these difficulties.

After many trials for developing the source data have been done, this paper can be developed with the practical data that contains many distinctive cases. These data can then be analyzed with several means of classification to extract meaningful findings. Hence, the outcomes of the research will result in a practical PSS business type, generic PSS business models, and new guidelines for PSS business development. In order to get those results, more than 1000 companies have been reviewed and more than 200 PSS business cases have been collected from diverse sources. Through analysis, 38 distinctive types of PSS business have been identified. Six new types of requirements for PSS are suggested and many other meaningful insights.

This research highlights several different perspectives of PSS and new findings that increase the potential of PSS. The potential of PSS is not isolated to improving any single manufacturing business or typical service business. Rather than incrementally improving a typical manufacturing or service business, this paper points out that PSS has strong potential for creating new types of business and new types of innovation. For example, PSS has many

unique features that cannot be observed in any other business system, such as dynamism in the PSS value chain, recursive innovation with key activities, restrictionless application in business or consumer lifecycles, etc.

Based on the descriptive analysis, this paper proposed 10 findings for unlocking the potential of PSS. <Finding 1> emphasized that the PSS business model can be applied to any business. <Finding 2> identified that PSS can be a practical convergence model. Generally, this convergence occurs at high-level terms. <Finding 3> presents that PSS has the characteristic of destructive innovation. In <Finding 4>, it is identified what PSS must have as components and activities. <Finding 5> shows that PSS is dynamic rather than static. In <Finding 6>, it is claimed that two key activities (servitization and productization) need be considered collectively. As show in ″Smile Curve,″ <Finding 7> suggested that PSS has potential applications, which can include generic models for total solutions for customers. In <Finding 8>, it is shown that diverse collaboration that improves convergence is another key success factor. <Finding 9> argues that it is necessary to develop a PSS business model or PSS business strategy as a starting point. In <Finding 10>, it is explained that PSS business practices diversify cost and revenue structures.

In the proposed business model, several unique differences become apparent upon comparison with typical business models. They explain how PSS is related to external factors. It is emphasized that PSS has a unique internal value chain in terms of value engagement, value innovation, and value participation. In terms of cost structure, there has not been enough research, and it is shown that PSS can have a cost and revenue stream and structure. For practicality, several high level checklists for individual PSS businesses are presented. These can also be used for PSS feasibility checks.

Along with the research of the business model, it is necessary to emphasize the importance of the technologies and methodologies that help make PSS available even though they are investigated minimally in this paper, as they are tightly linked to the PSS business model. The appropriate technologies or methodologies that fuse the characteristics of the core values and customers' needs are another key research area. "PSS technologies and methodologies" refers to appropriate technologies and methodologies rather than high or expensive technology. It is also noteworthy that Information and Communication Technologies have a critical role in PSS business models both generally and specifically.

Although this paper tried to identify the key aspects of PSS and develop practical tools with descriptive analysis approaches, there are still many unexplored research areas and pending questions. There are still arguments about data quality and the fact that qualitative analysis is still limited. The research data needs to be developed concisely on a more objective basis. Ultimately, subsequent works need to contribute to the research that proves that PSS helps businesses both financially and operationally with their objectives.

REFERENCE

1. Aapaoja, A., Kujaha, J., Pesonen, L.TT (2012), "Productization of University Services", International Journal of Synergy and Research, Vol. 1 No. 1, pp. 29-106.

2. AlajoutsijaÈrvi, K., Kari Mannermaa, K., Tikkanen, H. (2000), "Customer relationships and the small software firm A framework for understanding challenges faced in marketing", Information & Management, Vol. 37 Issue 3, pp 153-159.

3. Alonso-Rasgado, T., Thompson, G. and Elfström, B. (2004), "The design of functional (total care) products", Journal of Engineering Design, Vol.15 Issue 6, pp. 515-540.

4. Baines, T. S., Lightfoot, H. W., Evans, S., Neely, A., Greenough, R., Peppard J., Roy, R., Shehab, E., Braganza, A., Tiwari, A., Alcock, J., Angus, J. P. , Bastl, M., Cousens, A., Irving, P., Johnson, M., Kingston, J., Lockett, H., Martinez, V., Michele, P., Tranfield, D., Walton, I. M. and Wilson, H. (2007), "State of-the-art in product-service systems", Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture, Vol. 221 No. 10, pp. 1543-1552.

5. Baines, T., and Lightfoot, H. (2013), "MADE TO SERVE", WILLEY, UK

6. Barquet, A. P. B., Oliveira, M. G., Amigo, C. R., Cunha, V. P., and Rozenfeld, H. (2013), "Employing the business model concept to support the adoption of product–service systems", Industrial Marketing Management, Volume 42 Issue 5, pp. 693–704.

7. Berry, L. L., and Parasuraman, A. (1991), "Marketing Services: Competing Through Quality", New York:The Free Press.

8. Beuren, F. H., Ferreira, M. G. G., and Miguel, P .A. C. (2013), "Product-service systems: a literature review on integrated products and services", Journal of Cleaner Production, Vol. 47, pp. 222-231.

9. Chattopadhyay, N. (2012), "Productisation of Service: A Case Study", International Journal of Advanced Computer Science and Applications, Vol. 3, Issue 12, pp. 197-201.

10. Cleary, J. (2010), "The incorporation of waste prevention activities into life cycle assessments of municipal solid waste management systems: methodological issues", International Journal of Life Cycle Assessment, Vol 15 Issue 6, pp.579-589.

11. Ducq, Y., Chen, D., and Alix, T (2012), "Principles of Servitization and Definition of an Architecture for Model Driven Service System Engineering", International Federation for Information Processing 2012 IWEI 2012, LNBIP 122, pp. 117–128.

12. Fitzsimmons, J. A. (2010), "Service Management 7th ed", Trans., 서비스경영연구회, Korea.

13. Goedkoop, M. J., Halen, C. J. G., Riele, H. R. M., and Rommens, P. J. M (1999), "Product Service Systems, Ecological and Economic Basics", Report for Dutch Ministries of Environment(VROM) and Economic Affairs(EZ)

14. Jaakkola, E. (2011), "Unraveling the practices of "productization" in professional service firms", Scandinavian Journal of Management, Vol. 27 Issue 2, pp. 221-230.

15. Kaletsky, Anatole (2010), "Capitalism 4.0", Trans., 컬처앤스토리, Korea

16. Kang, M., and Wimmer, R. (2008), "Product service systems as systemic cures for obese consumption and production". Journal of Cleaner Production, Vol. 16 Issue 11, pp. 1146-1152.

17. Kestemont, B., and Kerkhove, M. (2010), "Material flow accounting of an Indian village", Biomass and Bioenergy, Vol. 34 Issue 8, pp. 1175-1182.

18. Kindström, D. (2010), "Towards a service-based business model – Key aspects for future competitive advantage", European Management Journal, Vol. 28, Issue 6, pp. 479-490.

19. Kotler, P. (2010), "Marketing 3.0", Trans., 타임비즈, Korea

20. Lee, H. (2010), "Consumer Behavior 5th ed", 법문사, Korea

21. Levitt, T. (1972), "Production-line approach to service", Harvard business review, Vol. 50, No. 5, 41-52.

22. Li, M. S., Zang, H. M., Li, Z., and Tong, L. J. (2010), "Economy-wide material input/output and dematerialization analysis of Jilin Province (China)", Environmental Monitoring and Assessment, Vol. 165 No. 1-4, pp. 263-274.

23. "Lightfoot, H., Baines T., and Smart, P. (2013), ""The servitization of manufacturing: A systematic literature review

24. of interdependent trends"", International Journal of Operations & Production Management, Vol. 33 No. 11/12 (2013), pp. 1408-1434."

25. Manzini, E., and Vezolli, C. (2003), "A strategic design approach to develop sustainable product service systems: examples taken from the 'environmentally friendly innovation' Italian prize", Journal of Cleaner Production, Vol. 11 Issue 8, pp. 851-857.

26. Maussang, N., Zwolinski, P. and Brissaud, D. (2009), "Product-service system design methodology: from the PSS architecture design to the products specifications", Journal of Engineering Design, Vol. 20 No. 4, pp. 349-366.

27. Maxwell, D., Sheate, W., and Vorst, R. (2006), "Functional and systems aspects of the sustainable product and service development approach for industry", Journal of Cleaner Production,   Vol. 14 No. 17, pp. 1466-1479.

28. Neely, A. (2007), "The servitization of manufacturing: An analysis of global trends", 14th European Operations Management Association Conference, Ankara, Turkey.

29. Oliva, R., and Kalleberg, R. (2003), "Managing the transition from products to services", International Journal of Service Industry Management, Vol.14 No.2, pp.160-172.

30. Osterwalder, A. (2011), "Business Model Generation", Trans., 유효상, 타임비즈, Korea

31. Park, P., and Ryu, S. (2013), "잘나가는 중소기업의 성공방식 : 제품의 서비스화", Institute for International Trade - Trade Focus, Korea, Vol 12 No. 30, pp 5-29

32. Park, Y. (2012), "Service Engineering", 생능출판사, Korea

33. Rifkin, Jeremy (2011), "The Third Industrial Revolution", Trans., 민음사, Korea

34. Robinson, T., C. M. Clarke-Hill and R. Clarkson (2002), "Differentiation through Service: A Perspective from the Commodity Chemical Sector", The Service Industries Journal, Vol. 22 No. 3, pp 149–166.

35. Ryu, J., Rhim, H., Park, K., and Kim, H. (2009), "A Study on Servitization Processes in Manufacturing Companies", 한국경영과학회/대한산업공학회 춘계공동학술대회(2009-05) 논문집, Korea, pp. 414-437.

36. Sakao, T. and Shimomura, Y. (2007), "Service Engineering: a Novel Engineering Discipline for Producers to Increase Value Combining Service and Product", Journal of Cleaner Production, Vol. 15 No.6, pp. 590-604.

37. Sakao, T., Shimomura, Y., Sundin, E. and Comstock, M. (2009), "Modeling design objects in CAD system for Service/Product Engineering", Computer-Aided Design, Vol. 41 No. 3, pp. 197-213.

38. Shih, S. (2001), "Growing Global", Willey, USA

39. Tukker, A. (2004), "Eight types of product–service system: Eight ways to sustainability? Experiences from SusProNet", Business Strategy and the Environment, Vol. 13 No. 4, pp. 246–260.

40. Vandermerwe, S., and Rara, J. (1988), "Servitization of Business: Adding Value by Adding Services", European Management Journal, Vol. 6 No. 4, pp 314-324.

41. Vijaykumar, G., Roy, R., Lelah, A., and Brissaud, Daniel. (2012), "A review of Product-Service Systems Design Methodologies", Journal of Engineering Design, Vol. 23 No. 9, pp. 635-659.

42. Vogtländer, J. G., Brezet, H. C., and Hendriks, C. F. (2001), "Allocation in recycling systems - An integrated model for the analyses of environmental impact and market value", The International Journal of Life Cycle Assessment, Vol.6 No.6, pp. 344-355.

43. Yang, X., Moore, P., Pu, J. S., and Wong, C. B. (2009), "A practical methodology for realizing product service systems for consumer products", Computers and Industrial Engineering, Vol. 56 No. 1, pp. 224-235.

TOWARD AND INTEGRATIVE MODEL OF EXPATRIATE ADJUSTMENT: ANTECEDENTS, MEDIATORS, AND CONSEQUENCES

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ABSTRACT

Purpose: This study aims to develop a research model that can integrate antecedents, mediators, and consequences of expatriate adjustment.

Design/methodology/approach: This study used Meta-Analysis to collect data from 140 studies during 1988-2013. Comprehensive Meta-Analysis software was adopted to integrate the study results buy calculating the correlation coefficients.

Findings: Based on the results of Meta-Analysis, the results indicated that while cross-cultural competences have positive effects on expatriates' dynamic competence, mainstream culture identification, perceived host attitude toward expatriate (PHATE) and expatriate adjustment, the degree of work role demands may have negative effects on these factors. Furthermore cross-cultural dynamic competences, mainstream cultural identification, and PHATE had positive effects on expatriates' effectiveness.

Research limitation/implications: The main limitation of this study is that this study applied meta-analysis method collecting data from many different studies that may have different measurement scales. This may create variations which may result in insignificant results.

Originality/value: This study developed a comprehensive research model and eight research hypotheses of expatriate adjustment and effectiveness that can be very useful for future focus.

Keywords: Cross-culture dynamic competence, Work–role demand, Expatriation effectiveness, Expatriate adjustment

Paper type: Research paper

RESEARCH BACKGROUND AND RESEARCH OBJECTIVES

With the increase of economic globalization, foreign direct investment flows have also rapidly increased around the world. Accordingly, multinational enterprises (MNEs) are required to send more local staffs abroad to work or hire more expatriates who are residing in the host country. However, despite the increasing need of MNEs to hire expatriates, expatriation is still an exceptionally challenging process for both expatriates and MNEs (Toh & Densi, 2007). To date, MNEs are still encountering problems with expatriation failures, turnover, and ineffective performance due to mal-adjustment, which, in turn result in both direct and indirect costs for MNEs (Takeuchi et al. 2002). Previous studies showed that approximately 30% to 50% of expatriate managers are ineffective or merely marginally effective (Wu & Bodigerel-Koehler, 2013). The direct costs incurred from expatriate adjustment failure have been estimated at US$ 150,000 per employee, while the expense for training, relocation, and compensation have been estimated at US$ 80,000 per employee (Shaffer et al., 2006). Accordingly, academic researchers, as well as corporate management of MNEs, are trying to find some solutions for the above issues. However, it is still very important for MNEs and expatriates to find justifications on why expatriates fail and determine ways to increase the probability of success in the host country.

Previous studies have investigated the effects of cross-cultural competencies, perceived host attitudes towards expatriates (PHATE), and identifications on expatriate effectiveness. However, none of them integrated those relevant constructs together to develop a more comprehensive framework. There is still a research gap with regards to a more theory-oriented explorations dealing with the integration of identifications, PHATE, cross-cultural competencies, and expatriate effectiveness. Therefore, this study aims to develop a model to identify the antecedents, mediators, and consequences of expatriates and empirically test its viability. Firstly, this study identified stable cross-cultural competencies and work role demand characteristics as the antecedents of expatriate adjustment. Secondly, innovative work behavior, expatriate performance, and expatriate satisfaction are classified as the consequences of expatriate adjustment. Thirdly, for the mediation effects, this study identified cross-cultural dynamic competencies and cross-cultural adjustment as mediation variables for the influence of cross-cultural static competences and work role demand on expatriate effectiveness. Relevant theories, such as theory of social categorization and social support (Hogg, et al., 2000; Caligiuri & Lazoravo, 2002), social learning theory (Bandura, 2002), and the theory of acculturation (e.g. Berry, 2005) are also integrated in this study to develop the research hypotheses. Fourthly, mediation effects of expatriate adjustment on the relation between identification with the mainstream culture and expatriate performance.

LITERATURE REVIEW

Cross-cultural stable competences

In this study, the Multicultural Personality Questionnaire (MPQ) is adopted to measure expatriates' cross-cultural stable competencies. According to previous studies, MPQ encompasses five dimensions, including cultural empathy, emotional stability, social initiative, open-mindedness, and flexibility (Zee & Oudenhoven, 2000; Oudenhoven & Zee, 2002). According to Wu and Bodigerel-Koehler (2013), cultural empathy refers to the ability and sensitivity to sympathize with the feelings, thoughts, and behaviors of expatriates from other cultural settings. Open-mindedness refers to an open and unbiased, nondiscriminatory attitude toward different cultural individual and cultural background, norms and values. Emotional stability is defined as the capability to conduct oneself appropriately under difficult conditions, such as when expatriates are experiencing a conflict in two new environments. Social initiative refers to expatriates' tendency to endeavor to achieve goals, to take initiative, and to solve problems. Flexibility refers to the ability to learn from previous mistakes and the ability to learn from new experiences and adopt stable strategies for the new environment.

Cross-cultural dynamic competences

Cross-cultural dynamic competencies refer to a set of specific behavioral contingencies, such as relational skills, non-ethnocentrism, and general self-efficacy which may be trainable through cross-cultural training or on-the-job training. Self-efficacy refers to expatriates' capability to perform the course of action required to manage prospective situation (Bandura, 1997). Self-efficacy also refers to expatriates' confidence in their capability to apply the cultural knowledge in a manner that permits coping with the stressors as posed by a particular cross-cultural environment (Leiba-O'Sullivan, 1999). General self-efficacy is related to the psychological adjustment with the expatriate employees (Wu & Bodigeler-Koehler, 2013; Siu, Lu & Spector, 2007).

In addition, ethnocentrism is defined as the tendency of expatriates to put their own group in a position of worth, and thus create negative attitude and behaviors toward other group. Non-ethnocentrism, which is the opposite of ethnocentrism, is the propensity to view expatriates' own culture as good as other culture (Shaffer, et al., 2006). Because ethnocentrism is hindrance to intercultural communication, non-ethnocentrism can facilitate expatriates intercultural communication competences.

Furthermore, relational skills are crucial for expatriates to develop the long-last relationship with host nationals. Relational skills refer to expatriates' willingness and ability to foster and maintain interpersonal relationship with host nationals and then deal with a diversity

of communication styles (Mendenhall & Oddou, 1985). Relational skills are extremely important to facilitate expatriate to communicate with people and to maintain conversational currency (e.g. antecedotes, jokes, proverbs, songs, sport, etc.) (Wu & Bodigeler-Koehler, 2013).

Work role demand

The predominant factor of work role demand (including role novelty, role ambiguity, role conflict, and role overload), have found to have significant and nagative influence on expatriates' adjustment and expatriation effectiveness, According to Konanahalli, et al. (2013), role novelty involves the differences between the past role and the new role. Black (1988) argued that if the new position of the overseas assignment is substantially different from the previous positions, then the expatriate may experience greater feelings of uncertainty and unpredictability with the results. This situation may become more for the expatriate to justify which behaviors are more appropriate for the new situation. Konanahalli, et al. (2013) also highlighted that, the transfer expatriate from one functional department to another, or to promote expatriate to another job with greater responsibility will create more stressful condition which will hinder the adjustment and reduce expatriate performance.

Identification with mainstream culture

The concept of acculturation is largely concerned with the changes of cultural attitudes, values, and behaviors, as a result of the connections between individuals of dissimilar culture groups (Ryder, et al., 2000; Sam & Berry, 2011). Recently, scholars have argued that, by adapting a new culture, expatriate do not necessary to give up their culture of origins and to have the contradictory experiences in adapting to the host culture (Kan, 2006; Lee, 2010). Ryder et al. (2000)(developed a two-dimensional approach (Vancouver Index of Acculturation, VIA) to identify the concept of acculturation: (1.) Identification with the mainstream culture, and (2.) identification with the heritage culture. This study will adopt Ryder et al.'s definition to further investigate the influence of acculturation factors on other relevant variables.

Expatriates' identification with both mainstream and heritage cultures can be determined by the extent to which those cultural groups are ready to help expatriates fulfill their specific needs. Specifically, the more the expatriates believe that the hosts have positive attitudes towards them and willingness to help them, the more will be the likelihood that they will identify with the mainstream culture. In other words, if hosts categorize expatriates as their in-group members and are keen to share with them vital information regarding work and the new culture, as well as to provide them with support, expatriates are likely to identify with the mainstream culture. If hosts, however, categorize expatriates as out-group members and are reluctant to provide them with information and support, expatriates might be also reluctant to identify with the mainstream culture. Berry (1997) suggested that ideologies and attitudes in dominant society influence the

acculturation strategies of immigrants, refugees, and sojourners. (Berry, 1997; Kosic et al., 2005; Yu & Wang, 2011). In relation to this point, Neto (2002) found that acculturation strategy preference is strongly dependent on majority identity and perceived discrimination.

Expatriate adjustment

Expatriate adjustment is generally conceptualized as the degree of psychological [dis-] comfort felt by expatriates associated with various aspects of the host culture (Black et al. 1991). Early studies on cross-cultural settings have conceptualized the degree of adjustment as a one-dimensional concept (Oberg 1960, Torbiorn 1982). However, contemporary research (Black 1988, Black et al. 1991, Bhaskar-Shrinivas et al. 2005; Ramalu et al., 2010; Zhou & Qin, 2009) has suggested that expatriate adjustment is a multidimensional concept with at least three facets: (1) work adjustment; (2) general adjustment; and (3) interaction adjustment. Work adjustment refers to expatriates' psychological comfort associated with assignments and duties abroad. Interaction adjustment is related to expatriates' psychological comfort associated with interaction with hosts both outside and inside work. General adjustment is described as the physical comfort related to general living conditions such as food, climate, and the transportation system in the new environment. Nevertheless, this study excludes general adjustment because its predictive power is not well confirmed (Wu and Bodigerel-Koehler, 2013). Instead, psychological adjustment is given prominence in this study, because Aycan (1997) implied that adjustment to the general environment is conceptually similar to psychological adjustment. Psychological adjustment is related to maintaining good mental health or psychological well-being in a new environment (Aycan, 1997; Selmer, 2002; Hervas & Vazguez, 2013). Psychological well-being has been defined as optimal psychological functioning and experience (Ryff & Keyes 1995, Springer & Hauser 2006). Wang and Kanungo (2004) highlighted that psychological well-being is an important indicator of expatriate adjustment. More specifically, they argued that since expatriation is a stressful matter, a decline in encountered stress or greater levels of psychological well-being would indicate adjustment.

Perceived host attitude towards expatriate

Perceived host attitude towards expatriate, (also recognized as PHATE) might be described as expatriates' perceptions of how host nationals behave towards them. More specifically, based on their interactions with hosts, expatriates have different perceptions in relation to the host attitudes towards them: Some of them perceive that they are victims of racial discrimination in the host country (Florkowski & Fogel 1999); others perceive that the hosts have trustworthiness or untrustworthiness toward them (Leung et al. 2009); and some female expatriates perceive that they cannot survive in the host country, while others believe that they can be successful there (Stone 1991, Caligiuri et al. 1999). Indeed, it is reasonable that expatriates have different perceptions about host attitudes towards them. Furthermore, host country has an important role

in expatriate adjustment process and performance, and their attitudes toward expatriates will influence or shape the way they behave to expatriates (Arman & Aycan, 2013).

Innovative work behavior

Drawing from West and Farr (1989, 1990b), Yuan and Woodman (2010) defined 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 is include searching out new technologies, suggesting new ways to achieve objectives, applying new work methods, and investigating and securing resources to implement new ideas. According to Spiegelaere et al. (2013), innovative work behavior is not only focused on creating the ideas, but also generating the behaviors to solve the problem, and then implement it. Therefore, 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 & 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).

Expatriate performance

Three facets of expatriate performance deserve further discussion: *Task performance* is the implementation of activities that related to the organization's technical core through both directly or indirectly using the technology, and using materials or service (Malek & Budhwar, 2013). According to Borman and Motowidlo (1993), task performance refers to successful execution of overseas duties, including attaining specific goals or accomplishing definable projects. It should be more strongly related to work adjustment. When tracked as a separate criterion dimension, *relationship (contextual) performance* is the effective development or maintenance of ties with members of the host country workplace. It is important to shape the organizational, social, and psychological context that are needed for task activities and process (Malek & Budhwar, 2013). Given its interpersonal substrates, it is expected that relationship performance is more strongly related to cultural and interaction adjustment. In addition, because some empirical articles have measured performance as a combination of task and relationship elements, we defined a third variable, overall performance. *Overall performance*, a global measure of effectiveness, includes

an individual's productivity and organizational contributions and the extent and quality of his or her execution of assigned duties, including task and relationship maintenance.

Expatriate satisfaction

Job satisfaction is defined as the extent to which a worker feels positively or negatively about his or her job (Locke, 1976; Odom et al., 1990). Job satisfaction is also defined as an affective or emotional response toward one's job (Kreitner and Kinicki, 1992). From an economic perspective, job satisfaction is a unitary concept that tends to be explained in purely monetary terms (Lazear, 2000). It is assumed that individuals like rewards but dislike effort. As a result, a better salary, for an identical level of effort, will determine the decision to quit and a higher level of satisfaction. From the lens provided by psychology and sociology, however, the employment relationship is about much more than the exchange of labour services for a pay-cheque. It is an economic relation in part, but it is a potent social and psychological one as well (Baron and Kreps, 1999). Thus, a person can be relatively satisfied with the absolute monetary rewards he or she receives and dissatisfied with how they fare relative to others (Festinger, 1954; Adams, 1965), or with other aspects of his or her job, either because they do not allow to fulfil his or her needs (Salansik and Pfeffer, 1977) and values (Locke, 1976) or because they do not met his or her expectations.

METHODOLOGY

Research Model

The main purpose of this study is to identify the antecedents, mediators, and consequences for expatriate adjustment. The research of this study is presented in Figure 1.

Meta-analysis

This study implemented a literature search from different scientific database in order to integrate the results of previous studies relevant to the topic of this study. Firstly, this study sought for relevant literature using the following keywords related to this study: MPQ personality, work role demand, expatriate adjustment, and expatriate performance. In the literature search, the following database were employed: JSTOR, Elsevier Science Direct, Wiley Online Library, and Taylor & Francis Online Journals. After completing the literature search, this study obtained a total of 140 studies done during 1988-2013 which related to the constructs of this study. In order to evaluate the studies to measure the effect size of the hypotheses, this study used correlation coefficient (r) between two variables.

Figure 1. Research Model

By using Comprehensive Meta-Analysis (CMA) software, the correlations were not only obtained from *r* value, but also from *t*-value, *z*-value, and *p*-value. Those values were converted to *r*-value by CMA software. The *r*-values as an effect size are then categorized into small (r < 0.1), medium (r = 0.25), and large (r > 0.40) (Lipsey & Wilson, 2001). The reason for using *r*-value as the primary effect size was because it was easier to be interpreted and most of previous meta-analytical review used *r*-value as the criteria (Byron & Khazanchi, 2010; Shrinivas & Shaffer, 2005; Hechenova, 2003).

Furthermore, to check the homogeneity of the effect size distribution, the Q-statistic test was adopted. Lipsey and Wilson (2001) explained that Q-statistic is distributed as a chi-square with degree of freedom = n-1, where n = number of studies. This Q-statistic test has assumed that all of the effect sizes as estimating the same population mean is a reasonable assumption. The criterion for Q-statistic is that Q-value should be higher than Chi-square, and then it suggests that the null hypothesis of homogeneity is rejected. In this case, it can be concluded that the

differences in effect size are attributed to factor other than sampling. Therefore, the heterogeneity between the variance existed. Furthermore, all the identified studies were examined in terms of following relevant variables: author, year, journal, total sample size, variables, and effect size.

RESULTS

The Effects of Cross-Cultural Static Competence and Work Role Demand on Cross-Culture Dynamic Competence

Table 1 shows the meta-analysis results for the influence of cross-cultural static competences and work role demand on cross-cultural dynamic variables. Using the mean values of correlation coefficients among previous studies, the results show that overall variables of cross-cultural static competences have positive influences on cross-cultural dynamic competencies (r=0.359). Based on the criteria as stated by Lipsey and Wilson (2001), the relationships has medium effect sizes. These results are supported by 95% confidence interval with non-zero values. Furthermore, the Q-value is higher than Chi-square value. It means that the influence significantly heterogeneous from the variance attributed to factors rather than from the sampling errors. Therefore, hypothesis 1 is supported. In contrary, work role demand has negative influences on cross-cultural dynamic competencies (r=-0.231). Therefore, hypothesis 2 is supported.

Table 1 Meta-Analysis Results for Cross-cultural dynamic competences variables

Hyp.	Variables		k	Total	Effect Size & 95% Confidance Interval			Heterogeneity			
	Independent	Dependent	Studies	n	r	LCI	UCI	p-value	Chi-square	Q-value	I-squared
H1	**Cross-cultural static competences (MPQ)**	**Cross-cultural dynamic competences**	**14**	**3723**	**0.359**	**0.330**	**0.387**	**0.000**	**34.53**	**130.300**	**90.023**
b	Cross-cultural static competences (MPQ)	General Efficacy	10	2695	0.405	0.373	0.436	0.000	27.880	91.109	90.122
c	Cross-cultural static competences (MPQ)	Non-ethnocentrism	4	1028	0.230	0.171	0.287	0.012	7.820	10.954	72.613
H2	**Work role demand**	**Cross-cultural dynamic competences**	**3**	**695**	**-0.231**	**-0.301**	**-0.159**	**0.040**	**5.99**	**6.431**	**68.902**
b	Work role demand	General Efficacy	3	695	-0.231	-0.301	-0.159	0.040	5.990	6.431	68.902

The Effects of Cross-Cultural Static Competence and Work Role Demand on Cross-Culture Adjustment

Table 2 shows the meta-analysis results for the influence of cross-cultural static competences and work role demand on cross-cultural adjutsment variables. Using the mean

values of correlation coefficients among previous studies, the results show that overall variables of cross-cultural static competences have positive influences on cross-cultural adjustment (r=0.248). Based on the criteria as stated by Lipsey and Wilson (2001), the relationships has medium effect sizes. These results are supported by 95% confidence interval with non-zero values. However, it is not significant because the p-value is higher than 0.05. Furthermore, the Q-value is higher than Chi-square value. It means that the effect is significantly heterogeneous from the variance attributed to factors rather than from the sampling errors. Therefore, hypothesis 3 is supported. In contrary, work role demand has negative influences on cross-cultural dynamic competencies (r=-0.153). Therefore, hypothesis 4 is supported.

Table 2 Meta-Analysis Results for Cross-cultural adjustment variables

Hyp.	Variables		k	Total	Effect Size & 95% Confidance Interval			Heterogeneity			
	Independent	Dependent	Studies	n	r	LCI	UCI	p-value	Chi-square	Q-value	I-squared
H3	**Cross-cultural static competences (MPQ)**	**Cross-cultural adjustment**	**21**	**2893**	**0.248**	**0.213**	**0.282**	**0.142**	**13.4**	**26.764**	**25.272**
b	Cross-cultural static competences (MPQ)	Expatriate adjustment	20	2788	0.240	0.204	0.275	0.301	15.4	21.671	12.326
H4	**Work role demand**	**Cross-cultural adjustment**	**22**	**2528**	**-0.153**	**-0.192**	**-0.115**	**0.000**	**46.8**	**80.255**	**73.833**
b	Work role demand	Expatriate adjustment	15	1933	-0.099	-0.143	-0.054	0.002	29.140	33.777	58.551
c	Work role demand	PHATE	7	595	-0.324	-0.395	-0.249	0.001	16.810	21.741	72.402

The Effects of Cross-Cultural Dynamic Competence and Cross-Culture Adjustment on Expatriate Effectiveness

Table 3 shows the meta-analysis results for the influence of cross-cultural dynamic competences and cross-cultural adjutsment on expatriate effectiveness variables. Using the mean values of correlation coefficients among previous studies, the results show that overall variables of cross-cultural dynamic competences have positive influences on expatriate effectiveness (r=0.289). Based on the criteria as stated by Lipsey and Wilson (2001), the relationships has medium effect sizes. These results are supported by 95% confidence interval with non-zero values. Furthermore, the Q-value is higher than Chi-square value. It means that the effect is significantly heterogeneous from the variance attributed to factors rather than from the sampling errors. Therefore, hypothesis 5 is supported. Similarly, the results show that overall variables of cross-cultural adjustment have positive influences on expatriate effectiveness (r=0.226). Therefore, hypothesis 6 is supported.

The Effects of Cross-Cultural Static Competence and Work Role Demand on Expatriate Effectiveness

Table 3 also shows the meta-analysis results for the influence of cross-cultural static competences and work role demand on expatriate effectiveness variables. Using the mean values of correlation coefficients among previous studies, the results show that overall variables of cross-cultural static competences have positive influences on expatriate effectiveness (r=0.300). Based on the criteria as stated by Lipsey and Wilson (2001), the relationships has medium effect sizes. These results are supported by 95% confidence interval with non-zero values. Furthermore, the Q-value is higher than Chi-square value. It means that the effect is significantly heterogeneous from the variance attributed to factors rather than from the sampling errors. Therefore, hypothesis 7 is supported. In contrary, work role demand has negative influences on expatriate effectiveness (r=-0.251). Therefore, hypothesis 8 is supported.

Table 3 Meta-Analysis Results for expatriate effectiveness variables

Hyp.	Variables		k	Total	Effect Size & 95% Confidance Interval			Heterogeneity			
	Independent	Dependent	Studies	n	r	LCI	UCI	p-value	Chi-square	Q-value	I-squared
H5	**Cross-cultural dynamic competences**	**Expatriate effectiveness**	**11**	**1939**	**0.289**	**0.247**	**0.329**	**0.000**	**29.59**	**90.691**	**88.974**
a	Cross-cultural dynamic competences	IWB	3	857	0.237	0.172	0.299	0.000	13.820	20.748	90.360
b	Cross-cultural dynamic competences	Expatriate performance	4	528	0.328	0.249	0.403	0.000	16.270	29.256	89.746
c	Cross-cultural dynamic competences	Expatriate Satisfaction	4	554	0.330	0.253	0.403	0.000	16.720	35.957	91.657
H6	**Cross-cultural adjustment**	**Expatriate effectiveness**	**34**	**12086**	**0.226**	**0.210**	**0.242**	**0.000**	**63.87**	**201.892**	**83.650**
b	Cross-cultural adjustment	Expatriate performance	25	11083	0.210	0.193	0.227	0.000	51.180	143.560	83.282
c	Cross-cultural adjustment	Expatriate Satisfaction	9	1003	0.420	0.368	0.471	0.417	6.58	8.169	2.073
H7	**Cross-cultural static competences (MPQ)**	**Expatriate effectiveness**	**20**	**1954**	**0.300**	**0.259**	**0.341**	**0.000**	**43.82**	**53.864**	**64.726**
b	Cross-cultural static competences (MPQ)	Expatriate performance	7	412	0.405	0.319	0.484	0.000	22.46	31.448	80.921
c	Cross-cultural static competences (MPQ)	Expatriate Satisfaction	13	1542	0.272	0.224	0.318	0.220	8.07	15.396	22.058
H8	**Work role demand**	**Expatriate effectiveness**	15	1573	-0.251	-0.298	-0.204	0.016	36.12	27.699	49.458
b	Work role demand	Expatriate performance	6	630	-0.164	-0.24	-0.086	0.301	3.01	6.056	17.439
c	Work role demand	Expatriate Satisfaction	8	931	-0.305	-0.363	-0.245	0.088	2.69	12.401	43.553

CONCLUSIONS AND SUGGESTIONS

The purpose of this study is to develop a research model that can integrate the antecedents, mediators, and consequences of expatriate adjustment. Several conclusions could be drawn from the result of this study. First, expatriate's cross-cultural static competences have significant impacts on cross-cultural dynamics competences and cross-cultural adjustment. These results are in line with those from Reegard (2011), Matsumoto, et al., (2013), Hunler (2012), Huang, et al., (2007), and Wu and Bodigerel-Koehler, 2013). Therefore, it is very important to recruit expatriates with higher MPQ scores. Most previous studies (Shaffer et al., 2006; Peltokorpi, 2008) examined the relationship between the Big Five Personality traits on expatriate adjustment and expatriate effectiveness, yet the predictive power was limited. The main reason is that the Big Five personality traits are too broad. It may not be able to predict expatriate effectiveness. This study thus adopts the concept of Wu and Bodigerel-Koehler (2013) who assert that, instead of the Big Five personality, expatriate competences may be more powerful to facilitate expatriate adjustment. Expatriate with higher MPQ scores tend to have higher level of cultural empathy, emotional stability, social initiative, open-mindedness and flexibility to handle the complexity of expatriate work and living environment, and thus are more easily to create their general self-efficacy and non-ethnocentrism. Several studies such as Huang, et al., (2007), Wu and Bodigerel-Koehler, 2013), Leiba-O'Sullivan (1999), and Shaffer et al., (2006) have mentioned that both static and dynamic cross-cultural competences are crucial for expatriate's identification with mainstream culture, perceived host attitude toward expatriate and work adjustment. Based on these results, human resource managers may have to develop a selection and training plan for expatriates to develop their static and dynamic competences. Second, expatriate work role demands have significant and negative influence on their general self-efficacy, PHATE, and work adjustment. These results are in line with those from Rizzo, et al. (1970), Karva and Nair (2010), Gist and Mitchell (1992), and Larazova, et al. (2010). These studies have mentioned that expatriate who are not familiar with the role of the overseas assignment may be unable to handle the new task, due to the increases of uncertainty, unfamiliarity, unpredictability, and uncontrollability of the new work assignment, which may result in expatriate failure (Morley & Flynn, 2003; Selmer & Fenner, 2009; Larazova, et al., 2010; Mahajan & Silva, 2012). Konanahalli, et al. (2013) indentified from kinds of work role demands: (1) role novelty, (2) role ambiguity, (3) role conflict, and (4) role overload. According to role theory (Rizzon, House, & Lirtzman, 1970), role ambiguity (lack of clear information about the new role) will experience anxiety, distort reality, increase dissatisfaction, which will further result in less effectiveness (Idris, 2011). Role conflict refers to a collection of roles that do not precisely fit, which may result in higher stress, less satisfy, and lower performance (Cervoni & Waack, 2011; Judeh, 2011). Black (1988) argued that when expatriates experiencing role conflict, they will be less able to determine which message should be ignored and when message should be followed, and

thereby which execution and behavior should result in better performance. Statt (1994) stated that work overload will result in stress, which will further result in respond inadequately, and adjustment poorly. Therefore, it is very important for expatriates to make sure that their work role demands are acceptable. To this aspects, fully communication and support from headquarter could be essential.

Third, expatriates' cross-cultural static competences (MPQ) and work role demands not only can influence their cross-cultural competences and cross-cultural adjustment, but also directly to expatriate effectiveness (including innovative work behavior, expatriate performance, and expatriate satisfaction). According to Baron and Kenny (1986), the influences of mediators should be evaluated based on the following criteria:

(1) To make a simple regression analysis with independent variable (X) predicting dependent variable (Y) to test whether the effect of X $\rightarrow$ Y is significant;

(2) To conduct a simple regression analysis with independent variable (X) predicting mediating variable (M) to test whether the effect of X $\rightarrow$ M is significant;

(3) To conduct a simple regression analysis with dependent variable (Y) predicting mediating variable (M) to test whether the effect of M $\rightarrow$ Y is significant;

(4) To make a multiple regression analysis with independent variable (X) and mediating variable (M) predicting Y to test whether X + M $\rightarrow$ Y is significant.

Since the antecedents (including cross-cultural static competence and work role demands) can either influence directly on expatriate effectiveness, or indirectly through cross-cultural dynamic competences and cross-cultural adjutsment, these later two constructs can be justified as partial mediators for the influence of antecedents on expatriate effectiveness.

Since previous studies never integrated these relevant constructs into a more comprehensive research model to identify the antecedents and mediators of expatriate adjustment and expatriation effectiveness, the results of this study can be provided as an important reference for academicians to conduct further empirical validations on the research of expatriation effectiveness. The study results can also be very useful for professionals to identify recruiting and management strategy of expatriates in order to increase the probability of success of expatriate assignments.

REFERENCES

1. Adams, J.S. (1965), *Inequity in social exchange*, In Berkowitz, L. (Ed.), Advances in Experimental Social Psychology, Vol. 2, Academic Press, New York, NY, pp. 267-99.
2. Amabile, T. M. (1988), "A model of creativity and innovation in organizations" In B. M. Staw & L. L. Cummings (Eds.), *Research in organizational behavior*, Vol. 10, 123–167. Greenwich, CT: JAI Press.
3. Arman, G., & Aycan, Z. (2013), "Host country nationals' attitudes toward expatriates: Development of a measure", *The International Journal of Human Resource Management,* Vol. 24, pp. 2927 – 2947.
4. Aycan, Z. (1997), "Expatriate adjustment as a multifaceted phenomenon: Individual and organizational level predictors", *The International Journal of Human Resource Management,* Vol. 8 No. 4, pp. 434-454.
5. Bandura, A. (2002), "Social cognitive theory in cultural context", *Applied Psychology: An International Review,* Vol. 51 No. 2, pp. 269-290.
6. Baron, J. and Kreps, D. (1999), *Strategic Human Resources: Frameworks for General Managers*, John Wiley & Sons, New York, NY.
7. Berry, J.W. (2005), "Acculturation: Living successfully in two countries", *International Journal of Intercultural Relations,* Vol. 29, pp. 697-712.
8. Bhaskar-Shrinivas, P., Harrison, D. A., Shaffer, M. A., and Luk, D. M. (2005), "Input-based and time-based models of international adjustment: Meta-analytic evidence and theoretical extensions", *Academy of Management Journal,* Vol. 48 No. 2, pp. 257-281.
9. Black, J. S. (1988), "Work role transitions: A study of American expatriate managers in Japan", *Journal of International Business Studies,* Vol. 19, pp. 277-294.
10. Black, J. S., Mendenhall, M., and Oddou, G. (1991), "Toward a comprehensive model of international adjustment: An integration of multiple theoretical perspectives", *Academy of Management Review,* Vol. 16, pp. 291-317.
11. Borman, W. C., and Motowidlo, S. J. (1993), "Expanding the criterion domain to include elements of contextual performance", In N. Schmitt, & W. C. Borman (Eds.), *Personnel Selection in Organizations*, San Francisco: Jossey-Bass, pp. 71-98.
12. Byron, K., and Khazanchi, S. (2010), "A meta-analytic investigation of the relationship of state and trait anxiety to performance on figural and verbal creative tasks", *Personality and Social Psychology Bulletin*, Vol. 37 No. 2, pp. 269–283.
13. Caligiuri, P.M. and Lazarova, M. (2002), "A model for the influence of social interaction and social support on female expatriates' cross-cultural adjustment", *The International Journal of Human Resource Management,* Vol. 13 No. 5, pp. 761-772.

14. Caligiuri, P.M., Joshi, A., and Lazarove, M. (1999), "Factors influencing the adjustment of women on global assignments", *International Journal of Human Resource Management*, Vol. 10 No.40, pp.163-179.

15. Cervoni. A., and DeLucia-Waack, J. (2011), "Role conflict and ambiguity as predictors of job satisfaction in high school counselors", *Orchard Park High School*, pp. 1-30.

16. Cohen, S. (1980), "After-effects of stress on human performance and social behavior: A review of research and theory", *Psychological Bulletin,* Vol. pp. 88, 82-108.

17. De Spiegelaere, S., Van Gyes, G., and Van Hootegem, G. (2012), *"*Job design and innovative work behavior: One size does not fit all types of employees", *Journal of Entrepreneurship, Management and Innovation (JEMI)*, Vol. 8 No 4, pp. 5-20.

18. Dean, J. W., Jr. (1987), "Building the future: The justification process for new technology", In J. M. Pennings & A. Buitendam (Eds.), *New technology as organizational innovation: The development and diffusion of microelectronics*, Cambridge, MA: Ballinger, pp. 35–58.

19. Dyer, W. G., and Page, R. A., Jr. (1988), "The politics of innovation", *Knowledge in the Society: An International Journal of Knowledge Transfer*, Vol. 1 No. 2, pp. 23–41.

20. Festinger, L. (1954), "A theory of social comparison processes", *Human Relations*, Vol. 7, pp. 117-140.

21. Florkowski, G.W. and Fogel, D.S. (1999), "Expatriate adjustment and commitment: The role of host-unit treatment", *The International Journal of Human Resource Management,* Vol. 10 No. 5, pp. 783-807.

22. Florkowski, G.W. and Fogel, D.S. (1999), "Expatriate adjustment and commitment: The role of host-unit treatment", *The International Journal of Human Resource Management,* Vol. 10 No. 5, pp. 783-807.

23. Gist, M. E. and Mitchell, T. R. (1992), "Self-efficacy: A theoretical analysis of its determinants and malleability", *Academy of Management Review,* Vol. 17 No. 2, pp. 183-211.

24. Handy, C. (1985), *Understanding Organizations*, London: Penguin Books.

25. Hechanova, R., Beehr, T. A., and Christiansen, N. D. (2003), "Antecedents and consequences of employees' adjustment to overseas assignment: A meta-analytic review, "*Applied Psychology: An International Review*, Vol. 52 No. 2, pp. 213-236.

26. Hervas, G. and Vazquez, C. (2013), "Priming the mental time-line: effects of modality and processing mode", *Cognitive Processing,* Vol. 14 No. 3, pp. 231-244.

27. Hogg, M.A. and Terry, D.J. (2000), "Social identity and self-categorization contexts", *Academy of Management Journal,* Vol. 25 No. 1.

28. Huang, T-J., Chi, S-C, and Lawler, J. J. (2007)' "The relationship between expatriates' personality traits and their adjustment to international assignments", *The International Journal of Human Resource Management,* Vol. 16 No. 9, pp. 1656-1670.

29. Hunler, O. S. (2012), "The factors predicting depression of expatriates in Turkey", *Psychology Research,* Vol. 2 No. 9, pp. 515-523.

30. Idris, M. K. (2011), "Over time effects of role stress on psychological strain among Malaysian public university academics", *International Journal of Business and Social Science,* Vol. 2 No. 9*,* pp. 154-161.

31. James, L. R., and Brett, J. M. (1984), "Mediators, moderators, and tests for mediation", *Journal of Applied Psychology*, Vol. 69, pp. 307-321.

32. Janssen, O. (2000), "Job demands, perceptions of effort-reward fairness and innovative work behavior", *Journal of Occupational and Organizational Psychology*, Vol. 73, pp. 287–302.

33. Judeh, M. (2011), "Role ambiguity and role conflict as mediators of the relationship between socialization and organizational commitment", *International Business Research*, Vol. 4, No. 3, pp. 171-181.

34. Kan, S.-M. (2006), "Measurement of acculturation, scale formats, and language competence", *Journal of Cross-Cultural Psychology,* Vol. 37 No. 6.

35. Kanter, R. M. (1988), "When a thousand flowers bloom: Structural, collective, and social conditions for innovation in organization", In B. M. Staw & L. L. Cummings (Eds.), *Research in organizational behavior*, Greenwich, CT: JAI Press, Vol. 10, pp. 169–211.

36. Karva, S., and Nair, S. K. (2010), "Role stress and coping with role stress among Indian women executives", *International Journal of Arts and Sciences,* Vol. 3 No. 12, pp. 57-85.

37. Konanahalli, A., Oyedeye, L., von Meding, J., Spillane, J., and Coates, R. (2013), "International projects and cross-cultural adjustment of British expatriates in Middle East: A qualitative investigation of influencing factors", *Australasian Journal of Construction Economics and Building,* Vol. 12 No. 3, pp. 31-54.

38. Kosic, A., Mannetti, L. and Sam, D.L. (2005), "The role of majority atttudes towards out-group in the perception of the acculturation strategies of immigrants", *Internationa Journal of Intercultural Relations,* Vol. 29, pp. 273-288.

39. Kreitner, R. and Kinicki, A. (1992), "*Organizational Behavior*, 2nd ed., Irwin, Boston, MA Lazear, E.P. (2000). The power of incentives", *The American Economic Review,* Vol. 90 No. 2, pp. 410-15.

40. Larazova, M., Westman, M., and Shaffer, M. A. (2010), "Elucidating the positive side of the work-family interface on international assignments: A model of expatriate work and family performance", *Academy of Management Review,* Vol. 35 No. 1, pp. 93–117.

41. Lazear, E.P. (2000), "The power of incentives", *The American Economic Review*, Vol. 90 No.2, pp. 410-15.

42. Leiba-O'Sullivan, S. (1999), "The distinction between stable and dynamic cross-cultural competencies: Implications for expatriate trainability", *Journal of International Business Studies*, Vol. 30 No. 4, pp. 709–725.

43. Leone, L., Van der Zee, K. I., Van Oudenhoven, J. P., Perugini,M., and Ercolani, A. P. (2005), "The cross-cultural generalizability and validity of the Multicultural Personality Questionnaire", *Personality and Individual Differences,* Vol. 38*,* pp. 1449–1462.

44. Leong, C.-H. (2007), "Predictive validity of the Multicultural Personality Questionnaire: A longitudinal study on the socio-psychological adaptation of Asian undergraduates who took part in a study-abroad program", *International Journal of Intercultural Relations*, Vol. 31, pp. 545–559.

45. Leung, K., Zhu, Y. and Ge, C. (2009), "Compensation disparity between locals and expatriates: Moderating the effects of perceived injustice in foreign multinationals in China", *Journal of World Business,* Vol. 44, pp. 85-93.

46. Linebery, M. (2012), "Expatriates' Acculturation Strategies: Going beyond "How Adjusted Are You?" To "How Do You Adjust?", *University of South Florida.*

47. Locke, E.A. (1976), "The nature and causes of job satisfaction", In Dunnette, M.C.(Ed.), *Handbook of Industrial and Organizational Psychology*, Sage, Beverly Hills, CA, pp. 1297-349.

48. Mahajan, A. (2011), "Host country national's reactions to expatriate pay policies: Making a case for a cultural alighnment pay model", *The International Journal of Human Resource Management,* Vol. 22 No. 1, pp. 121-137.

49. Malek, M A., and Budhwar, P. (2013), "Cultural intelligence as a predictor of expatriate adjustment and performance in Malaysia", *Journal of World Business,* Vol. 48, pp. 222–231.

50. Matsumoto, D., and Hwang, H. C. (2013), "Assessing cross-cultural competence: A review of available tests", *Journal of Cross-Cultural Psychology,* Vol. 44 No. 6, pp. 849-873.

51. Mendenhall, M., and Oddu, G. (1985), "The dimensions of expatriate acculturation: A review", *Academy of Management Review*, Vol. 10 No.1, pp.39-47.

52. Morley, M. J. and Flynn, M. (2003), "The relationship between work-role characteristics and intercultural transitional adjustment domain patterns among a sample of US and Canadian expatriates on assignment in Ireland", *Cross Cultural Management,* Vol. 10 No. 3, pp. 42-57.

53. Neto, F. (2002), "Acculturation strategies among adolescents from immigrant families in Portugal", *Internationa Journal of Intercultural Relations,* Vol. 26 No. 1, pp. 17-38.

54. Oberg, K., (1960), "Culture shock and the problem of adjustment in new cultural environments", *Practical Anthropology,* Vol. 7, pp. 177-182.

55. Odom, R.Y., Boxx, W.R. and Dunn, M. (1990), "Organizational cultures, commitment, satisfaction and cohesion", *Public Productivity and Management Review,* Vol. 14 No. 2, pp. 157–169.

56. Oldham, G. R., and Cummings, A. (1996), "Employee creativity: Personal and contextual factors at work", *Academy of Management Journal*, Vol. 39 No. 3, pp. 607–634.

57. Olsen, J. E., and Martins, L. L. (2009), "The effects of expatriate demographic characteristics on adjustment: a social identity approach", *Human Resource Management*, Vol. 48 No. 2, pp. 311-328.

58. Ones, D. S., and Viswesvaran, C. (1997), "Personality determinants in the prediction of aspects of expatriate job success", In Z. Aycan (Ed.), *New Approaches to Employee Management,* Greenwich, CT: JAI, Vol. 4, pp. 63-92.

59. Peltokorpi, V. (2008), "Cross-cultural adjustment of expatriates in Japan", *The International Journal of Human Resource Management*, Vol. 19 No. 9, pp. 1588–1606.

60. Ramalu, S. S., Rose, S. C., Kumar, N., and Uli, J. (2010), "Personality and expatriate performance: The mediating role of expatriate adjustment", *The Journal of Applied Business Research,* Vol. 26 No. 6, pp. 113-122.

61. Reegard, K. (2011), 'Facilitating Cross-cultural Adjustment: The Case of North European Expatriates in China', *University of Oslo.*

62. Rizzo, J., House, R. and Lirtzman, S. (1970), "Role conflict and ambiguity in complex organizations", *Administrative Science Quarterly*, Vol. 15, pp. 150-163.

63. Ryder, A.G., Alden, L.E. and Paulhus, D.L. (2000), "Is acculturation unidimensional or bidimensional? : A head-to-head comparison in the prediction of personality, self-identity, and adjustment", *Journal of Personality and Social Psychology,* Vol. 79 No. 1, pp. 49-65.

64. Ryff, C.D. & Keyes, C.L.M. (1995), "The structure of psychological well-being revisited", *Journal of Personality and Social Psychology,* Vol. 69 No. 4, pp. 719-727.

65. Salansik, G. and Pfeffer, J. (1977), "An examination of need satisfaction models of job attitudes", *Administrative Science Quarterly*, Vol. 22 No. 3, pp. 427-39.

66. Sam, D. L. and Berry, J. W. (Eds.). (2006), *Cambridge Handbook of Acculturation Psychology*, Cambridge: Cambridge University Press.

67. Scott, S. G., and Bruce, R. A. (1994), "Determinants of innovative behavior: A path model of individual innovation in the workplace", *Academy of Management Journal,* Vol. 37 No. 3, pp. 580–607.

68. Selmer, J., and Fenner Jr, Charles R. (2009), "Spillover effects between work and non-work adjustment among public sector expatriates", *Personnel Review*, Vol. 38 No. 4, pp. 366-379.

69. Shaffer, M.A., Harrison, D.A., Gregersen, H., Black, J.S. and Ferzandi, L.A. (2006), "You can take it with you: Individual differences and expatriate effectiveness", *Journal of Applied Psychology,* Vol. 91 No. 1, pp. 109-125.

70. Siu, O.-l., Lu, C.-Q., and Spector, P.E. (2007), "Employees' well-being in greater China: The direct and moderating effects of general self-efficacy", *Applied Psychology: An International Review,* Vol. 56 No. 2, pp. 288–301.

71. Springer, K.W. and Hauser, R.M. (2006), "An assessment of the construct of ryff's scales of psychological well-being: Method, mode and measurement effect", *Social Science Research,* Vol. 35 No. 4.

72. Statt, D. (1994), *Psychology and the World of Work*, Basingstoke: Macmillan.
73. Stone, R. (1991), "Expatriate selection and failure", *Human Resource Planning,* Vol. 14, pp. 9-18.
74. Takeuchi, R., Yun, S. and Russel, J.E.A. (2002), "Antecedents and consequences of perceived adjustment of Japanese expatriates in the USA", *The International Journal of Human Resource Management,* Vol. 13 No. 8, pp. 1224-1244.
75. Toh, S.M. and Densi, A.S. (2007), "Host country nationals as socializing agents: A social identity approach", *Journal of Organizational Behavior,* Vol. 28, pp. 281-301.
76. Torbiorn, I. (1982), *Living Abroad: Personal Adjustment and Personnel Policy in the Overseas Setting,* New York: Wiley.
77. Varma, A., Budhwar, P. and Pichler, S. (2011a), "Chinese host country national's willingness to help expatriates: The role of social categorization", *Thunderbird International Business Review,* Vol. 53 No. 3, pp. 353-364.
78. Varma, A., Pichler, S. and Budhwar, P. (2011b), "Host country national willingness to help expatriates: The role of social categorization and exchange", *The International Journal of Human Resource Management,* in press.
79. Vernaik, S., Midgley, D. F., and Devinney, T. M. (2005), "Dual paths to performance: The impact of global pressures on MNC subsidiary conduct and performance", *Journal of International Business Studies*, Vol. 36, pp. 655-675.
80. Wang, X. and Kanungo, R.N. (2004), "Nationality, social network and psychological well-being: Expatriates in China" *International Journal of Human Resource Management,* Vol. 15 No. 4, pp. 775-793.
81. West, M. A., and Farr, J. L. (1989), "Innovation at work: Psychological perspectives", *Social Behavior*, Vol. 4, pp. 15–30.
82. West, M. A., and Farr, J. L. (1990), "Innovation at work. In M. A. West & J. L. Farr (Eds.)", *nnovation and creativity at work: Psychological and organizational strategies,* Chichester, U.K.: Wiley, pp. 3–13.
83. Wolfe, R. A. (1994, "Organizational innovation: Review, critique and suggested research directions", *Journal of Management Studies*, Vol. 31, pp. 405–431.
84. Wu, W-Y., and Bodigeler-Koehler, M. (2013), "The mediating effects of cross-cultural dynamic competencies on the relationship between multicultural personality and cross-cultural adjustment", *The International Journal of Human Resource Management,* Vol. 24 No. 21, pp. 4026–4045.
85. Yu, W., and Wang, S. (2011), "An investigation into the acculturation strategies of Chinese students in Germany", *Intercultural Communication Studies,* Vol. 20 No. 2.
86. Yuan, F-R., and Woodman, R. W. (2010), "Innovative behavior in the workplace: The role of performance and image outcome expectations", *Academy of Management Journal,* Vol. 53 No. 2, pp. 323–342.

87. Zee, K.I.V.D., and Oudenhoven, J.P.V. (2000), "The Multicultural Personality Questionnaire: Multidimensional instrument of multicultural effectiveness", *European Journal of Personality*, Vol. 14, pp. 291–309.

88. Zee, K.I.V.d., and Oudenhoven, J.P.V. (2001), "The Multicultural Personality Questionnaire: Reliability and validity of self - and other ratings of multicultural effectiveness", *Journal of Research in Personality*, Vol. 35, pp. 278–288.

89. Zhou, X. and Qin, J. (2009), "A study on cross-cultural adjustment of Japanese and American expatriates in China", *International Journal of Business and Management*, Vol. 4 No. 12.

MOTIVATION, CAPABILITY, AND PERFORMANCE OF R&D ALLIANCE WITH ENVIRONMENTAL UNCERTAINTY

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ABSTRACT

Purpose: This study aims (1) to investigate whether R&D alliances with different oriented motives tend to obtain different organizational capabilities and NPD performance; (2) to identify the interrelationships between motives of R&D alliance, organizational capabilities, and NPD performance; (3) to evaluate the moderating effects of environment uncertainty on the relationship between organizational capabilities and NPD performance.

Design/methodology/approach: This study used quantitative study with questionnaire approach to collect the data. The respondents were 124 firms from "The Largest 2000 Firms in Taiwan". SPSS software was used to analyze the results.

Findings: The results indicate that stronger formation motives of R&D alliance will lead to better NPD performance and better organizational capabilities. Environmental uncertainty has the moderating effect that can reduce the positive effect of organizational capabilities on NPD performance.

Research limitation/implications: Since previous studies have largely ignored the influences of organizational capabilities and environmental uncertainty on R&D alliance success the results of this study can provide important references for professional managers in the business sector to develop a better operation mode of R&D alliance. These study results can also be very helpful for academicians to engage in further validations in this issue.

Originality/value: This study examined R&D alliances with different oriented motives tend to obtain different organizational capabilities and NPD performance. Furthermore, this study examined the moderating effects of environment uncertainty on the relationship between organizational capabilities and NPD performance.

Paper Type: Research Paper

INTRODUCTION

Technological collaboration among independent firms has become more common in recent years, partly because the technology base for industries has been expanding steadily and partly because the cost and risk for many kinds of technology development have been rising rapidly. In addition, globalization of competition have further intensified the need for inter-firm cooperation or partnering. R&D alliance is one of cooperative agreements aims at joint innovative efforts that can have a lasting effect on the product-market positioning. Therefore, the R&D alliance has grown in an unprecedented scale (e.g., Hagedoorn & Schakenraad, 1990a,b; Mytelka, 1991; Oxley & Sampson, 2004). This increase can be attributed to the present rapid changes in technological development, the necessity of quick preemption strategies, the management of complexities and uncertainties, and the necessity for large firms to monitor a wide spectrum of technologies.

Most of these alliances have been conducted in the information technology industry, covering personal computers, work stations, servers and multimedia, as well as a range of telecommunications and data switching systems. But recent alliances have also emerged in other sectors such as automotive engines, motor cycles, electric vehicles, and service industry. As the result, on what advantages do a firm entering into a R&D alliance have and how to form a successful R&D alliance have become important strategic issues for managers. One stream of studies has focused on the critical factors for the success of R&D alliance (Chen & Karami, 2012). Another stream of studies has focused on the motives of alliance formation (Mukherjee et al., 2013). The other stream of previous studies has paid more attention to the individual issue such as strategic model choice, knowledge sourcing, and organizational learning of R&D alliance (Un, et al., 2010).

Furthermore, Verona (1999) argues organizational capabilities are the critical factors for the performance of new product development. To develop new products is one of the main objects to firms in R&D alliance. However, little research has been done on investigating the effect of the formation motives of R&D alliance on the new product development performance and the organizational capabilities. Therefore, this study intends to investigate the relationships among motives of firms entering into R&D alliance, organizational capabilities obtaining from R&D alliance and new product development (NPD) performance.

In addition, environmental uncertainty is high due to the rapid change and great progress of technology, and it is a big challenge to firms. Souder & Moenaert (1992) suggest it is necessary to organization success that reduces the environment uncertainty. A firm that unable to effectively respond to the changes in environment cannot survive in the extremely competitive industry. Organizational theory suggests that environmental uncertainty significantly impacts organizational structure and performance. Khanna, et al., (1998) argue that firms must to find out the impact of environment uncertainty on organizational operation by monitoring the trends and events of environment for sustaining the competition advantage. Furthermore, perceived degrees of environment uncertainty have significant impact on alliance formation and performance (e.g., Kale & Singh, 1999; Mukherjee, et al., 2013). As the result, this study also tries to find the moderating effect on organizational capabilities and the performance of new product development.

Based upon the above discussions, the research objectives of this study are as follows:
1. To investigate whether R&D alliance with different oriented motives tend to obtain different organizational capabilities and different level of NPD performance.
2. To identify the interrelationships between motives of R&D alliance, organizational capabilities, and NPD performance.
3. To evaluate the moderating effects of environment uncertainty on the relationship between organizational capabilities and NPD performance.

LITERATURE REVIEW

Interrelationship between Motives of R&D Alliance and NPD Performance

Some prior studies implied that formation motives, inter-firm diversity, and partner interaction may affect the alliance. However, little has been done on empirically examining their effects on the alliance performance (Lin & Chen, 2002). Scholars taking the strategic behavior viewpoint argued that firms would do inter-firm cooperation to gain access to necessary resources from outside to enhance their competence (Harrigan, 1988). Different oriented formation motives will lead to different level of alliance performance, and that formation motives are positively related to alliance performance (Lai & Chang, 2010).

In R&D alliance, NPD performance is one of the important items to evaluate the R&D alliance performance. However, prior research has left two important questions unanswered. Will the firms, with different motive joining the R&D alliance, get different levels of NPD performance? Will the degrees of motives affect the level of NPD performance? Firms with competition-oriented motive such as competing against common competitors will cooperate more closely since the partners face the same threat and the alliance may immediately strengthen their competitiveness. On the other hand, alliances with the purpose of technology development

may have trouble at the end because of interest conflicts among the partners. To the extent that is the case, it would be expected that NPD performance would vary with the motive settings. Moreover, no matter what type of motive for joining the R&D alliance, as the motive is strong enough, firms will overcome any obstacles in front of the R&D alliances to achieve the goals (Lin & Chen, 2002; Lai and Chang, 2010). In light of the reasoning, the following hypotheses are proposed:

H1: *Different oriented formation motives of R&D alliance will lead to different level of NPD performance.*
H2: *The motives of R&D alliance are positively related to NPD performance.*

Interrelationship between Motives of R&D Alliance and Organizational Capabilities Obtaining from R&D Alliance

Firms have been increasingly willing to participate in R&D alliance for a variety of motives. Several authors argue that, in many instances, firms enter into alliances to acquire new skills or technologies from the partner (Sambasivan, et al., 2013). Balakrishnan & Koza (1993) pointed that R&D alliance can be used as means of obtaining resources because information sharing through partners and control can enable firms to reduce the transaction costs associated with arms-length transactions. Many firms have come to rely on alliances as strategic necessities for sustaining competitive advantage and creating customer value (Suh, et al., 2012).

Extant literature argues that a major benefit arising out of alliance is the opportunity for learning (e.g., Inkpen, 1998). Alliances provide firms the dynamic advantage to develop, cheaply and more quickly, new capabilities beyond inherited ones (Gomes-Casseres, 1996). So in a sense, the alliance creates a laboratory for learning (Khalid and Larimo, 2012). Indeed, Hamel (1991) has described learning between alliance partners as a race, where firms compete against each other to see which side can be faster in using the alliance to learn, accumulate knowledge, and build capabilities. More recent work has also highlighted alliances for their abilities to allow firms to learn from partners and internalize complex capabilities (Yoshino & Rangan 1995, Doz & Hamel, 1998). Firm realizes that no company is strong in all aspects, there are opportunities for exchanging resources with potential competitors, and that such alliances can be a win-win game, it may be able to avoid such a defensive attitude, and make better use of the alliance as a tool for efficient capability-building. For a firm that is confident of its own ability to assess its resource position, learn effectively from an alliance partner and thereby reinforce its capabilities, an alliance makes sense as a means to pursue capability building competition.

Furthermore, acquisitions are often only possible at a price that precludes an acquiring firm from earning above-normal profits as a result of the acquisition (Barney, 1997; Lubatkin, 1987, Singh & Montegomery, 1987). Thus, the new alliance pattern can permit a firm to secure

privileged access to the valuable capabilities of another firm at a reduced cost, and so may be considered a more efficient use of firm resources (Sambasivan, et al., 2013).

More and more firms have resorted to strategic alliance partnerships in recent times as a means of creating organizational capabilities. These hybrid, inter-organizational structures are becoming essential features for sustaining advantage in today's intensely competitive marketplace. The motives to enter into alliances are compelling and often explicit: gaining access to specific markets or distribution channels, acquiring new technologies, leveraging on economies of scale and scope, and enhancing new product development capabilities (Yasuda, 2005).

Alliance through the mechanism of organizational learning not only can achieve the key technological abilities of both alliance parties, but also can acquire or learn the integrated core knowledge and synergy of both parties (Yasuda, 2005). Prior studies paid more attention to the individual issue such as partner choice, and organizational learning of R&D alliance but less to, or even none at all to the integrated effects of organizational capabilities obtaining from R&D alliance and motives of R&D alliance (Doz & Hamel, 1998; Hamel, 1991; Yasuda, 2005). Thus, following hypotheses are proposed:

H3: *Different oriented formation motives of R&D alliance will lead to different organizational capabilities obtaining from R&D alliance.*
H4: *The motives of R&D alliance are positively related to organizational capabilities obtaining from R&D alliances.*

Interrelationship between Organizational Capabilities Obtaining from R&D Alliance and NPD Performance

In R&D alliances, firms obtain complementary resources and capabilities to improve the performance of organizational learning and technology (Lorenzoni & Lipparini, 1999; Van & Weggeman, 2000; Un, et al., 2010). Firms tend to learn and transfer technology in R&D alliances, and then become firms' competition advantages. Strategically, alliances are designed to build on core competencies, strengthen research and technology capabilities, address asymmetries in skill endowments of firms, accelerate new product development, reduce cost of entry into new markets and lead to higher capacity utilization and economies of scale (Haeussler, et al., 2012).

Staring with the path-breaking article by Wernerfelt (1984), the resource-based view of the firm has evolved from the effort of several scholars. Scholars in resource-based view suggested that firms coordinated with others to reinforce their resources and competitions. In Verona's (1999) research, he used a resource-based model to describe the capabilities already identified in

the empirical literature on new product development. Efficiency and effectiveness are appropriate dependent variables with which to study the impact of organizational capabilities on NPD performance (McGrath, Tsai, Venkatataman, & MacMillan, 1996). In Verona's research model, technological capabilities, external integrative capabilities, and internal capabilities are positively correlated with process efficiency. Also, external integrative capabilities, internal capabilities, and marketing capabilities are positively correlated with product effectiveness. Thus, the following hypothesis is proposed:

H5: Organizational capabilities obtaining from R&D alliance have positive impact on NPD performance.

The Moderating Effects of Environment Uncertainty

Organization's inability to evaluate and predict environmental uncertainty influences organizational processes and strategy (Mukherjee, et al., 2013). Souder & Moenaert (1992) suggested that it is necessary for organization success to reduce the environment uncertainty. Khanna, et al., (1998) argued that firms must find out the impact of environment uncertainty on organizational operation by monitoring the trends and events of environment for sustaining the competition advantage. Perceived degrees of environment uncertainty have significant impact on alliance formation and performance (e.g., Kale and Singh, 1999; Mukherjee, et al., 2013). In other words, the higher the degree of environment uncertainty, the more will be the negative impact on alliance performance.

Previous research further suggested that the NPD process and outcomes are dependent upon the level of perceived uncertainty regarding the external environment (e.g., Burns & Stalker, 1994). Burns and Stalker (1994) argued that the basic information gathering tasks required for successful innovation differ in emphasis according to the level of perceived environmental uncertainty. A resource-based view of the firm also suggested that various factors external and internal to a firm can neutralize or dissipate a resource's comparative advantage (Barney, 1991; Peteraf, 1993; Yasuda, 2005; Sambasivan, et al., 2013).

Therefore, a firm may fail to modify its resources in response to a change in the technological environment. As a result, a capability or resource that was once an asset can become a liability if it is no longer appropriate for the NPD project (Reed & DeFillippi, 1990). Similarly, Leonard-Barton (1992) contends that core capabilities in NPD can become core rigidities in the face of changing technological environments. In other words, proficiency in marketing, technical and competitive intelligence activities may not be as beneficial in highly uncertain technological environments (Song & Montoya-Weiss, 2001; Yeung, et al., 2013). For example, in high perceived technical uncertainty, customer need identification and translation into product technical specifications may be very challenging, and it may require altogether

different marketing and technical capabilities. Thus, we expect that environment uncertainty will weaken the positive effects of organizational capabilities obtaining from R&D alliance on NPD performance. Based on discussions above, the following hypothesis is proposed:

H6: The positive relationship between organizational capabilities and NPD performance will be weakened if the environment uncertainty is high.

RESEARCH DESIGN AND METHODOLOGY

Research Framework

Based on the above literature review and hypotheses development this study developed the research framework as shown in Figure 1. It suggests that, the motives of R&D alliance have an impact on the organizational capabilities which obtaining from R&D alliance. The organizational capabilities obtaining from R&D alliance have an impact on the performance of new product development. In addition, the factors of the environment uncertainty serve as the moderating variables that can reduce the influences of organizational capabilities on the performance of new product development.

Figure 1 Research Model

Construct Measurement

In this study, four major constructs are operationalized: (1) motives of R&D alliance, (2) organizational capabilities obtaining from R&D alliance, (3) NPD performance, and (4) environment uncertainty. The measurement items of motives of R&D alliance was adopted from Fang (1998), including (a) cost oriented motive (4 items); (b) technological learning oriented motive (5 items); (c) market strategy oriented motive (5 items); and (d) resource dependency oriented motive (5 items).

Organizational capabilities obtaining from R&D alliance items and NPD performance items were adopted from Verona (1999). Items of organizational capabilities are (a) technological capabilities (4 items); (b) external integrative capabilities (4 items); (c) internal integrative capabilities (4 items); and (d) marketing capabilities (4 items). Items of NPD performance are (a) process efficiency (3 items) and (b) product effectiveness (3 items). Furthermore, environmental uncertainty items were adopted from Bensaou and Venkatraman (1995), including (a) environment complexity (3 items); (b) market dynamics (3 items); and (c) technical maturity (4 items).

Questionnaire Items Purification and Sampling Plan

This study designed a preliminary version of questionnaire and conducted an expert interview to investigate the content validity of the questionnaire items that fit in the R&D alliance. Then, this study designed a survey questionnaire to identify managers' perceptions on the research constructs of this study. A pilot study was conducted with reliability test to ensure the data reliability and validity. The final version of questionnaire items was refined through a process of purification. Six hundred sample firms were selected. The sampling frame was adopted from "The Largest 2000 Firms in Taiwan". The respondents were asked to express their opinions about (a) the motives of R&D alliance, (b) organizational capabilities obtaining from R&D alliance, (c) NPD performance, and (d) environment uncertainty of the firms. Respondents were asked to indicate their level of agreement toward each statement, from 1=strongly disagree to 5=strongly agree.

RESULTS AND DISCUSSIONS

Descriptive Analysis

For the final survey, a total of 600 survey questionnaires were e-mailed to the sample firms. Out of 600 sample firms, 133 questionnaires were collected, producing a response rate of 22.2%. There were nine missing data among the 133 questionnaires; all of the remaining questionnaires were usable.

For the basic attributes of the sample firms, the most part of the sample firms are in the information and electrical industries. More than 68.5% of the firms operate more than 10 years. More than 37.1% of the firms have capital more than 1 billion NTD, and 74% of the firms have the annual sales more than 1 billion NTD. Thirty-four percent of the firms have employees less than 1500 people.

Furthermore, for the characteristics of the respondents, 33.1% of the respondents are managers. More than 69.3% of the respondents have work for the firm more than 5 years. More than 65% of the respondents' education degree are graduate or PhD. More than 60% of the respondents' ages are more than 40 years old.

Factor Analysis and Reliability

To ensure the dimensionality and reliability of the research constructs, this study conducted factor analysis, item-to-total correlation, and Cronbach's alpha tests. Table 1 shows that factor loadings of all the questionnaire items are higher than 0.7 (0.736-0.955), all item-to-total correlation coefficients are higher than 0.5 (0.552-0.913), and Cronbach's alpha of all the factors are also higher than 0.7 (0.779-0.939), which all exceed the generally accepted guideline from Hair, et al. (2010). So that we can conclude that all of the questionnaire items show high degree of internal consistency and their factors are appropriated to be used for further analysis.

Table 1 Factor Analysis and Reliability

Research Constructs	Factors	Factor Loadings	Eigen value	Percentage of Variance Explained	Item to total correlation	Cronbach 's α
Motives of R&D Alliance	Cost	0.804-0.907	2.207	73.583%	0.587-0.759	0.819
	Technological Learning	0.818-0.914	3.599	71.978%	0.717-0.849	0.902
	Market Strategy	0.832-0.879	2.226	74.194%	0.636-0.712	0.825
	Resource Dependency	0.756-0.879	2.616	65.388%	0.572-0.758	0.822
Organizational Capabilities	Technological	0.736-0.868	2.569	64.228%	0.552-0.724	0.812
	External Integrative	0.821-0.869	2.839	70.965%	0.682-0.752	0.863
	Internal Integrative	0.790-0.914	3.020	75.509%	0.653-0.833	0.890
	Marketing	0.873-0.955	3.388	84.695%	0.784-0.913	0.939
Environment Uncertainty	Market Uncertainty	0.787-0.833	3.345	41.301%	0.672-0.792	0.868
	Technology	0.795-0.829	2.051	67.452%	0.556-0.595	0.779

Research Constructs	Factors	Factor Loadings	Eigen value	Percentage of Variance Explained	Item to total correlation	Cronbach 's α
	Uncertainty					
NPD Performance	Process Efficiency	0.861-0.927	2.434	81.135%	0.706-0.815	0.883
	Product Effectiveness	0.891-0.898	2.403	80.088%	0.752-0.764	0.875

Comparisons of Research Constructs with Different Oriented Motives of R&D Alliance

Table 2 shows that the four clusters are significantly different (F=51.343, p<0.001). It shows that group one has significant higher scores in cost oriented motive which including cost sharing, reduce cost of information search, and reduce cost of risk motives. Group two has significant higher scores in technological learning oriented motive which means the main motives of the firms are skill sharing, learning, and training. Group three has significant higher scores in market strategy oriented motive than others. It means the firms of group three try to engage in R&D alliance for market sharing, economic scale, and more cooperative opportunities. Group four has significant higher scores in resource dependency oriented motive than others. Therefore, we named group one as cost oriented group (n=40), group two as technological learning oriented group (n=33), group three as market strategy oriented group (n=31) and group four as resource dependency oriented group (n=20). The p-values of all four cultures are extremely significant.

Table 2 Cluster Analysis of Motives of R&D Alliance

Name of Factor	Group1 Cost (n=40)	Group2 Learning (n=33)	Group3 Market (n=31)	Group4 Resource (n=20)	F	p	Duncan
Cost	5.00	3.33	2.33	1.00	51.722	0.000	(4,3,2,1)
Technological Learning	3.60	5.00	2.00	3.60	55.013	0.000	(3,1,4,2)
Market Strategy	2.33	4.67	4.00	1.67	64.318	0.000	(41,2,3)
Resource Dependency	2.75	4.50	2.00	3.75	21.383	0.000	(31,4,2)

Table 3 shows that companies in the "resource dependency oriented" group have the lowest scores on all of the two individual NPD performance items: process efficiency and product effectiveness. Companies in the "technological learning oriented" group have highest levels of process efficiency on NPD performance items (F=9.883, p=0.000). Besides, companies in the

"market strategy oriented" group have highest levels of product effectiveness on NPD performance items (F=2.888, p=0.038). In addition, companies in the "cost oriented" group have the mid-level of process efficiency on NPD performance items. Therefore, hypothesis 1 is supported.

Table 3 Variations in NPD Performance and Organizational Capabilities by Oriented Motives of R&D Alliance

Name of Factor	**Group1 Cost (n=40)**	**Group2 Learning (n=33)**	**Group3 Market (n=31)**	**Group4 Resource (n=20)**	**F**	**P**	**Duncan**
NPD Performance							
Process Efficiency	3.5999	4.1414	3.4085	3.1500	9.883	0.000	(43,31,2)
Product Effectiveness	3.1667	3.1919	3.6452	3.0333	2.888	0.038	(412,3)
Organizational Capabilities Obtaining from R&D Alliance							
Technological	3.4563	4.3030	3.3629	3.7375	19.060	0.000	(31,4,2)
External Integrative	2.9938	3.7576	3.4839	3.5125	6.323	0.001	(1,342)
Internal Integrative	3.1000	3.4621	3.5000	3.3125	2.217	0.09	(1423)
Marketing	2.9313	3.4773	4.1210	2.5500	18.386	0.000	(41,2,3)

Furthermore, Table 3 also shows that technological learning oriented motive tends to obtain more technological capabilities (F=19.060, P=0.000) and marketing strategy oriented motive tends to obtain more marketing capabilities (F=18.386, p=0.000). In the external integrative capabilities, cost oriented motives tends to obtain less than the other three oriented motives (F=6.323, p=0.001). In the internal integrative capabilities, all of four oriented motives have no significant difference between themselves (F=2.217, p=0.09). In conclusion, (1) when the motive of firms engage into R&D alliance is technological learning oriented motive, firms obtain more technological capabilities; (2) when firms engage into R&D alliance with market-strategy oriented motive, they obtain more marketing capabilities and obtain less technological capabilities; (3) when firms engage into R&D alliance with cost oriented motive, they obtain less external integrative capabilities, less technological capabilities and less market capabilities (Verona, 1999; Arvanitis, 2012). Hence, hypothesis 3 is supported.

Interrelationships among Research Constructs
Effects of Motive of R&D Alliance on NPD Performance

Table 4 shows that a firm's process efficiency is significantly influenced by cost motives (β=0.467, p<0.001), technological learning motive (β=0.282, p<0.001), market strategy motive

(β=0.203, p<0.001), and resource dependency motive (β=0.235, p<0.01). The significantly positive coefficients in the regression model indicate that higher degree of motives of R&D alliance contributes to higher degree of process efficiency. R&D alliance intending to acquire process efficiency should have more motives to engage in R&D alliance, especially in cost and technological learning motives.

Table 4 also shows that a firm's product effectiveness in NPD performance significantly influenced by market strategy motive (β=0.349, p<0.001), and resource dependency motive (β=0.248, p<0.05). The significantly positive coefficients indicate that the exercise of marketing strategy and resource dependency contribute to higher degree of product effectiveness. It is identical with the study of Lin & Chen (2002), Chen & Wu (2005), and Sambasivan, et al. (2013) that firm's formation motives of alliance positively associated with its alliance performance. Thus, hypothesis 2 is supported.

Table 4 Effects of Motives of R&D Alliance on NPD Performance

Independent Variables	Dependent Variables	
	Process Efficiency	**Product Effectiveness**
Cost	0.511***	0.061
Technological Learning	0.282***	-0.087
Market Strategy	0.225**	0.352***
Resource Dependency	0.221**	0.212*
R^2	0.474	0.180
Adjusted R^2	0.456	0.152
F-value	26.795	6.511
p-value	0.000	0.000
*p-value<0.05, **p-value<0.01, ***p-value<0.001		

Effects of Motives of R&D Alliance on Organizational Capabilities

Table 5 shows that a firm's technological capabilities in organizational capabilities obtaining from R&D alliance is significantly influenced by technological learning motive (β=0.594, p<0.001), and market strategy motive (β=0.122, p<0.05). The significantly positive coefficients indicate that higher degree of motives of R&D alliance contributes to higher degree of technological capabilities.

Table 5 also shows that a firm's external integrative capabilities in organizational capabilities obtaining from R&D alliance significantly influenced by cost motive (β=-0.152, p<0.05), market strategy motive (β=0.327, p<0.001), and resource dependency motive (β=0.501, p<0.001). The

significantly positive coefficients indicate that higher degree of motives of R&D alliance contributes to higher degree of external integrative capabilities.

Furthermore, Table 5 shows that a firm's internal integrative capabilities in organizational capabilities obtaining from R&D alliance significantly influenced by market strategy motive ($\beta=0.209$, $p<0.01$), and resource dependency motive ($\beta=0.399$, $p<0.001$). The significantly positive coefficients indicate that higher degree of motives of R&D alliance contributes to higher degree of internal integrative capabilities.

In addition, Table 5 shows that a firm's marketing capabilities in organizational capabilities obtaining from R&D alliance significantly influenced by market strategy motive ($\beta=0.845$, $p<0.001$). The significantly positive coefficients indicate that higher degree of motives of R&D alliance contributes to higher degree of marketing capabilities.

The above results are in line with Yasuda (2005). The primary motivation of company in entering into strategic alliances is their access to various resources owned by partners which enhance the organizational capabilities. It can be concluded that hypothesis 4 is supported.

Table 5 Effects of Motives of R&D Alliance on Organizational Capabilities

Independent Variables	Dependent Variables			
	Technological Capabilities	External Integrative Capabilities	Internal Integrative Capabilities	Marketing Capabilities
Cost	-0.089	-0.158*	0.004	-0.107**
Technological Learning	0.691***	0.092	0.036	-0.047
Market Strategy	0.157*	0.346***	0.243**	0.733***
Resource Dependency	0.087	0.448***	0.392***	-0.069
R^2	0.564	0.437	0.246	0.550
Adjusted R^2	0.549	0.418	0.220	0,535
F-value	38.466	23.091	9.683	36.327
p-value	0.000	0.000	0.000	0.000
*p-value<0.05, **p-value<0.01, ***p-value<0.001				

Effects of Organizational Capabilities on NPD Performance

Table 6 shows that a firm's process efficiency in NPD performance is significantly influenced by technological capabilities ($\beta=0.309$, $p<0.01$), and internal integrative capabilities ($\beta=0.233$, $p<0.05$). The significantly positive coefficients indicate that higher degree of organizational capabilities contributes to higher degree of process efficiency. It is identical with

the study of Verona (1999) that firm's organizational capabilities positively associated with its process efficiency.

Table 6 also shows that a firm's product effectiveness in NPD performance significantly influenced by marketing capabilities ($\beta=0.328$, $p<0.001$). The significantly positive coefficients indicate that higher degree of organizational capabilities contributes to higher degree of product effectiveness. It is identical with the study of Verona (1999) that firm's organizational capabilities positively associated with its product effectiveness. Thus, hypothesis 5 is supported.

Table 6 Effects of Organizational Capabilities on NPD Performance

Independent Variables	Dependent Variables	
	Process Efficiency	**Product Effectiveness**
Technological	0.267**	-
External Integrative	-0.019	0.160
Internal Integrative	0.223*	0.096
Marketing	-	0.381***
R^2	0.159	0.273
Adjusted R^2	0.138	0.255
F-value	7.562	15.020
p-value	0.000	0.000
*p-value<0.05, **p-value<0.01, ***p-value<0.001		

Moderating Effect of Environment Uncertainty

Previous studies concluded contradictory results to the moderating effects of environmental uncertainty on the relationship between organizational capabilities and NPD performance. Two factors, MU (market uncertainty) and TU (technical uncertainty), were used to represent environment uncertainty.

Table 7 shows the regression results of the moderating effect of market uncertainty on organizational capabilities and NPD performance. It reveals that the market uncertainty will weaken the effects of technological capability ($\beta=-0.511$, $p<0.001$), external integrative capability ($\beta=-0.220$, $p<0.05$), and internal integrative capability ($\beta=-0.225$, $p<0.05$) on process efficiency. On the other hand, market uncertainty will weaken only the effect of market capability ($\beta=-0.253$, $p<0.01$) on product effectiveness.

Table 7 Moderating Effects of Market Uncertainty on NPD Performance

Independent Valuables	Dependent Valuable: Process Efficiency			Dependent Valuable: Product Effectiveness		
	M1	**M2**	**M3**	**M4**	**M5**	**M6**
Technological	2.145***	-	-	-	-	-
External Integrative	-	1.028**	-	1.041**	-	-
Internal Integrative	-	-	1.108**	-	0.813	-
Marketing	-	-	-	-	-	1.310***
Market Uncertainty	-2.161***	-0.945**	-1.034**	-0.763*	-0.709	-1.060***
Technological x Market Uncertainty	-0.511***	-	-	-	-	-
External Integrative x Market Uncertainty	-	-0.220*	-	-0.180+	-	-
Internal Integrative x Market Uncertainty	-	-	-0.225*	-	-0.137	-
Marketing x Market Uncertainty	-	-	-	-	-	-0.253**
R^2	0.335	0.185	0.224	0.209	0.160	0.373
Adj-R^2	0.318	0.165	0.205	0.189	0.139	0.358
F	20.117	9.104	11.559	10.576	7.630	23.832

***: $p<0.001$; **: $p<0.01$; *: $p<0.05$

Table 8 shows that technological uncertainty has no moderating effect on the relationship between organizational capabilities and NPD performance (e.g., β=-0.166, 0.021, -0.003, -0.118, -0.089, 0.046, respectively). Although technological uncertainty has no moderating effect, but market uncertainty has moderating effect on the relationship between organizational capabilities and NPD performance, so that it can be concluded that the results support Song & Montoya-Weiss (2001) finding that environment uncertainty has moderating effects on NPD performance. Therefore, H6 is partially supported.

Table 8 Moderating Effects of Technical uncertainty on NPD Performance

Independent Valuables	Dependent Valuable: Process Efficiency			Dependent Valuable: Product Effectiveness		
	M7	M8	M9	M30	M11	M12
Technological	0.925***	-	-	-	-	-
External Integrative	-	0.140**	-	0.294***	-	-
Internal Integrative	-	-	0.678*	-	0.561***	-
Marketing	-	-	-	-	-	0.242**
Technical Uncertainty	-0.654***	-0.002	-0.445***	-0.106	-0.406***	-0.002
Technological x Technical Uncertainty	-0.166	-	-	-	-	-
External Integrative x Technical Uncertainty	-	0.021	-	-0.003	-	-
Internal Integrative x Technical Uncertainty	-	-	-0.118	-	-0.089	-
Marketing x Technical Uncertainty	-	-	-	-	-	0.046
R^2	0.143	0.074	0.117	0.149	0.106	0.253
Adj-R^2	0.122	0.051	0.095	0.128	0.084	0.234
F	6.697	3.189	5.300	7.029	4.741	13.515

***: $p<0.001$; **: $p<0.01$; *: $p<0.05$

CONCLUSIONS AND SUGGESTIONS

Research Conclusions

The major objectives of this study are first to identify the interrelationships among motives of R&D alliance, organizational capabilities obtaining from R&D alliance, and NPD performance. Second, the moderating effects of environment uncertainty to the relationships. Based on the results of this study, several conclusions could be drawn.

The first conclusion is that there are significant relationships between motives of R&D alliance and NPD performance. Different oriented formation motive will lead to different level of NPD performance. Firms joining the R&D alliances with technological learning oriented motive have the best process efficiency on NPD performance while firms joining the R&D alliances with market strategy oriented motive and resource dependency oriented motive have the worst process efficiency on NPD performance. In addition, firms with marketing strategy oriented motive achieve higher degree of product effectiveness on NPD performance than firms with the other three oriented motives (Arvanitis, 2012).

The second conclusion that can be drawn in this research is that different oriented motives of R&D alliance tend to obtain different organizational capabilities (Sambasivan, et al., 2013). Several reasons may contribute to these results. Firstly, firms with technological learning oriented motive tend to obtain more technological capabilities than firms with the other three oriented motives. Second, firms with marketing strategy oriented motive tend to obtain more marketing capabilities than firms with the other three oriented motives. In the external integrative capabilities, firms with cost oriented motive tend to obtain less than the other three oriented motives. Finally, in the internal integrative capabilities, all of four oriented motives have no significant difference between themselves. In conclusion, when the motive of firms into R&D alliance is technological learning oriented, firms obtain more technological capabilities than firms with other motives. When firms into R&D alliance with market oriented motive, they obtain more marketing capabilities than other firms, but obtain less technological capabilities. Moreover, when firms into R&D alliance are with oriented motive, they obtain less external integrative capabilities more than other firms, and also obtain less technological capabilities and less market capabilities.

The third conclusion is about the relationship between the organizational capabilities obtaining from R&D alliance and NPD performance. This finding consistent with Verona (1999), who found that technological capabilities, external integrative capabilities, and internal integrative capabilities have positive influence to process efficiency, and external integrative capabilities, internal integrative capabilities, and marketing capabilities have positive influence to product effectiveness. In this study, there is partial positive relationship between organizational capabilities and NPD performance (Khalid and Larimo, 2012; Suh, et al., 2012). Technological capabilities and internal integrative capabilities show the positive effect to process efficiency but the external integrative capabilities and marketing capabilities don't have significant relationships to process efficiency. Besides, marketing capabilities have positive effects to product effectiveness but technological capabilities, external integrative capabilities and internal integrative capabilities don't have significant relationships to product effectiveness.

The fourth conclusion is market uncertainty has negative moderating effect on organizational capabilities and NPD performance, but technical uncertainty is not. When the market uncertainty is high, the positive relationship between organizational capabilities and NPD performance will be weakened. From that conclusion, it may have the following managerial implications. Several researches suggest that environment uncertainty has the negative impact on NPD performance (Yeung, et al., 2013; Burns & Stalker, 1994; Capon, et al., 1992; Zirger & Maidique, 1990). It is a challenge to managers to reduce the impact of environment uncertainty. Souder & Moenaert (1992) suggest it is necessary to organization success that reduces the environment uncertainty. Firms usually use the way of entering a R&D alliance to reduce the risk of new product development. As the results of study, market uncertainty has the moderating effect on

organizational capabilities and NPD performance. In the other hand, if the market uncertainty is high, such as many competitors in industry, customers hope the types of products or materials change fast, industry need sensitive to the change of market information, the technological level of company's industry is relatively complicated, and the variation of industry's technology is relatively high, the impacts of organizational capabilities on NPD performance are lower. Therefore, firms should reduce the uncertainty of the market as much as possible. For example, firms can strengthen the integration of R&D and marketing, and establish cross-functional team to monitor the change of market more effectively.

REFERENCES

1. Arvanitis, S. (2012), "How do different motives for R&D cooperation affect firm performance? – An analysis based on Swiss micro data", *Journal of Evolutionary Economics*, Vol. 22, 981–1007.

2. Balakrishnan, S., and Koza, M. P. (1993), "Information asymmetry, adverse selection and joint ventures: Theory and evidence", *Journal of Economic Behavior and Organization*, Vol. 20, pp. 99-117.

3. Barney, J. B. (1991), "Firm resources and sustained competitive advantage", *Journal of Management*, Vol. 17, pp. 99-120.

4. Barney, J. B. (1997), *Gaining and Sustaining Competitive Advantage*, Reading, Mass.: Addison-Wesley Pub.Co.

5. Bensaou, M., and Venkatraman, N. (1995), "Configurations of interorganizational relationships: A comparison between U.S. and Japanese automakers", *Management Science*, Vol. 41 No. 9, pp. 1471-1492.

6. Burns, T., and Stalker, G. M. (1994), *The Management of Innovation*, Cambridge: Oxford University Press.

7. Capon, N., Farley, J., Lehmann, D., and Hulbert, J. (1992), "Profiles of product innovators among large US manufacturers", *Management Science*, Vol. 38 No. 2, pp. 157-169.

8. Chen, D., and Karami, A. (2010), "Critical success factors for inter-firm technological cooperation: an empirical study of high-tech SMEs in China", *International Journal Technology Management*, Vol. 51 No. 2/3/4, pp. 282-299.

9. Chen, C. J., and Wu, W. Y. (2005), "A comparative study of the alliance experiences between US and Taiwanese firms", *International Journal Technology Management*, Vol. 29 No. 1-2, pp. 136-151.

10. Doz, Y. L., and Hamel, G. (1998), *Alliance Advantage: The Art of Creating Value Through Partnering*, Boston: Harvard Business School Press.

11. Fang, S. C. (1998), "The consortia formed between industry and research institution: the features、interaction mechanisms and performance", *Journal of Management*, Vol. 16 No. 4, pp. 633-659. (in Chinese)

12. Gomes-Casseres, B. (1996), *The Alliance Revolution: The New Shape of Business Rivalry*, Cambridge, MA: Harvard University Press.

13. Hagedoorn, J., and Schakenraad, J. (1990), "A comparison of private and subsidized inter-firm linkages in the European IT industry", *Journal of Common Market Studies*, Vol. 31, pp. 373-390.

14. Hair, J. F., Black, W. C., Babin, B. J., and Anderson, R. E. (2010), *Multivariate Data Analysis: A Global Perspective*, 7th ed, Prentice Hall.

15. Hamel, G. (1991), "Competition for competence and inter-partner learning within international strategic alliances", *Strategic Management Journal*, Vol. 12, pp. 83-103.

16. Harrigan, K. R. (1988), "Joint ventures and competitive strategy", *Strategic Management Journal*, Vol. 9 No. 2, pp. 141-158.

17. Haeussler, C., Patzelt, H., and Zahra, S. A. (2012), "Strategic alliances and product development in high technology new firms: The moderating effect of technological capabilities", *Journal of Business Venturing*, Vol. 27, 217–233.

18. Inkpen, A. (1998), "Learning, knowledge acquisition, and strategic alliances", *European Management Journal*, Vol. 16, pp. 223-229.

19. Kale, P., and Singh, H. (1999), "Alliance Capability and Success: A. Knowledge Based Approach", *Academy of Management Proceedings*.

20. Khalid, S., and Larimo, J. (2012), "Affects of alliance entrepreneurship on common vision, alliance capability and alliance performance", *International Business Review*, Vol. 21, 891–905.

21. Khanna, T., Gulati, R., and Nohria, N. (1998), "The dynamics of learning alliances, Competition, cooperation and relative scope", *Strategic Management Journal*, Vol. 19 No. 3, pp. 193-210.

22. Lai, W. H., and Chang, P. L. (2010), "Corporate motivation and performance in R&D alliances", *Journal of Business Research*, Vol. 63, pp. 490-496.

23. Leonard-Barton, D. (1992), "Core capabilities and core rigidities: A paradox in managing new product development," *Strategic Management Journal*, Vol. 13 Summer Special Issue, pp. 111-125.

24. Lin, B., and Chen, C. (2002), "The effects of formation motives and interfirm diversity on the performance of strategic alliance", *Asia Pacific Management Review*, Vol. 7 No. 2, pp. 139-166.

25. Lorenzoni, G., and Lipparini, A. (1999), "The leveraging of interfirm relationships as a distinctive organizational capability: A longitudinal study", *Strategic Management Journal*, Vol. 20, pp. 317-338.

26. Lubatkin, M. (1987), "Merger strategies and stockholder value", *Strategic Management Journal*, Vol. 8, pp. 39-53.

27. McGrath, R. G., Tsai, M., Venkataraman, S., and MacMillan, I. C. (1996), "Innovation, competitive advantage and rent: A model and test", *Management Science*, Vol. 42, pp. 389-403.

28. Mukherjee, D., Gaur, A. S., Gaur, S. S., and Schmid, F. (2013), "External and internal influences on R&D alliance formation: Evidence from German SMEs", *Journal of Business Research*, Vol. 66, pp. 2178-2185.

29. Mytelka, and Lynn K. (1991), *Strategic Partnerships and the World Economy*, London: Pinter.

30. Oxley, J. E., and Sampson, R. C. (2004), "The scope and governance of international R&D alliances", *Strategic Management Journal*, Vol. 25, pp. 723-749.

31. Peteraf, M. (1993), "The cornerstones of competitive advantage: A resource-based view," *Strategic Management Journal*, Vol. 14 No. 3, pp. 179-191.

32. Porter, M. E. (1985), "Changing patterns of international competition," *California Management Review*, Vol. 18 No. 2, pp. 9-40.

33. Reed, R. and DeFillippi, R. J. (1990), "Causal ambiguity, barriers to imitation and sustainable competitive advantage," *Academy of Management Review,* Vol. 15, pp. 88-102.

34. Sambasivan, M., Siew-Phaik, L., Mohamedd, Z. A., and Leong, Y. C. (2013), "Factors influencing strategic alliance outcomes in a manufacturing supply chain: Role of alliance motives, interdependence, asset specificity and relational capital", *International Journal Production Economics*, Vol. 141, pp. 339-351.

35. Singh, H. and Montgomery, C. A. (1987), "Corporate acquisition strategies and economic performance", *Strategic Management Journal*, Vol. 8, pp. 377-386.

36. Song M., and Montoya-Weiss, M. (2001), "The effects of perceived technological uncertainty on Japanese new product development", *Academy of Management Journal*, Vol. 44 No. 1, pp. 61-80.

37. Souder, W. E., and Moenaert, R. K. (1992), "Integrating marketing and R&D project personnel within innovation projects: an information uncertainty model", *Journal of Management Studies*, Vol. 29 No. 4, pp. 485-512.

38. Suh, S. H., Ko, J. O., and Lee, S. Y. (2012), "An empirical study on the success factors of inter-firm alliances for new product development: With a focus on the SMEs in Korea", *Asian Journal of Innovation and Policy*, Vol. 1, 071 – 091.

39. Un, C. A., Cuervo-Cazurra, A., and Asakawa, K. (2010), "R&D collaborations and product innovation", *Journal of Product Innovation Management*, Vol. 27, pp. 673–689.

40. Van Aken, J. E., and Weggeman, M. P. (2000), "Managing learning in informal innovation networks: Overcomming the Daphne-dilemma", *R&D Management*, Vol. 30 No. 2, pp. 139-149.

41. Verona, G. (1999), "A resource-based view of product development", *Academy of Management Review*, Vol. 24 No. 1, pp. 132-142.

42. Wernerfelt, B. (1984), "A resource-based view of the firm", *Strategic Management Journal*, Vol. 5 No. 2, pp. 171-180.

43. Yasuda, H. (2005), "Formation of strategic alliances in high-technology industries: Comparative study of the resource-based theory and the transaction-cost theory", *Technovation*, Vol. 25, pp. 763-770.

44. Yeung, K., Lee, P. K. C., Yeung, A. C. L., and Cheng, T. C. E. (2013), "Supplier partnership and cost performance: The moderating roles of specific investments and environmental uncertainty", *International Journal of Production Economics*, Vol. 144, 546–559.

45. Yoshino M. and Rangan, R. (1995), "Strategic alliances: An entrepreneurial approach to globalization", *Harvard Business School Press*, Vol. 19.

46. Zirger, B. J., and Maidique, M. A. (1990), "A model of new product development: An empirical test", *The Institute of Management Sciences*.

BUILDING DISTINCTIVE INNOVATIVE CAPABILITY FOR SUPPLY CHAINS: THE ROLE OF RELATIONAL GOVERNANCE

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ABSTRACT

What we know about innovation and the strategies adopted by companies seem to fall short of today's dynamic competition rules. In this paper, we make a strong argument that this problem can be attributed to the failure to recognize the supply chain as the new competing and innovating unit. More specifically, companies that are under-performing seem to fall behind in building a collective capability for their supply chains to innovate. We define supply chain distinctive innovative capability as a high, effective and responsive ability of a competing supply chain to produce innovations. We proceed to practically ground this theory by using four case studies to highlight the significance of relational elements among partners in achieving this level of capability.

Keywords: supply chain innovation; relational governance; Resource-based view; Social Exchange Theory; Case studies

INTRODUCTION

Recent models of shared value creation (Porter and Kramer, 2011), open source technologies (Dooley and O'Sullivan, 2007), and distributed innovation (Cash et al., 2008) highlight the fact that company's ultimate innovation outcomes depend not only on its capability to innovate, but indeed on others' capabilities as well. Acknowledging the supply chain (SC) as the evolving unit of competition (Capaldo, 2007; Ketchen and Hult, 2007), it also represents a necessary "innovation ecosystem" (Adner, 2006) that must be properly managed for reaching the desired innovation outcome. Accordingly, this paper addresses how innovative capability can be developed on the level of the SC. We introduce "SC distinctive innovative capability" as a path to sustainable competitive advantage, exploring its relational antecedents. By combining theoretical insights from the Resource Based View (RBV), Social Exchange Theory (SET), and practical insights from four case studies, we propose a theory for SCs to achieve sustainable advantage through joint innovation.

Distinctive capabilities and their rent-generating power are well grounded in the Organizational Theory literature (Capaldo, 2007; Lorenzoni and Lipparini, 1999; Snow and Hrebiniak, 1980). As a subset of such, we conceptually define "distinctive innovative capability" as a high, effective and responsive ability of a competing SC to produce innovations. We further argue that firms will only achieve distinctive innovative capability by working toward the establishment of linkage-specific relational norms, of which we suggest four: network orientation, opportunity seeking, power imbalance and reciprocity. These antecedents can handle the flexibility, responsiveness and speediness requirements of distinctive innovative capability and, therefore, have a particular relevance to its cultivation. Recognizing these antecedents helps answer the "how" question that explains what needs to be done, giving managers an ex ante expectation of innovation performance with partners.

This research is relevant and timely in addressing a growing academic and practitioner interest in: (1) examining the *process* of SC innovation; and, (2) adopting a relational perspective when dealing with SC innovation. Researchers have long appreciated the importance of the innovation process on innovation outcomes, as learning outcomes directly depend on the learning process (Van-Maanen and Schein, 1977). Appropriating value from tangible resources depends heavily on how these resources are combined and applied (Patnayakuni et al., 2006). This means that the process of joint innovation itself carries substantial value for SCs, where relevant knowledge is not only physically and temporally distributed in the extended enterprise (Patnayakuni et al., 2006), but is also readily transferred among partners, both deliberately and unintentionally. It is, therefore, imperative to dedicate substantial attention to the SC innovation process.

On another frontier, little is known about the role of relational governance in SC innovation. This is surprising given the fact that the uncertainty of the SC innovation process favors informal and flexible relations (Wathne and Heide, 2004; Williamson, 1991). Being a bilateral governance mechanism, relational norms are based on mutual adjustment and partner flexibility, both of which match the uncertainty of innovation processes (Dwyer et al., 1987; Griffith and Myers, 2005). Accordingly, this study proceeds to explore relational elements that are particularly relevant to and can stimulate SC innovation, leading to a joint distinctive capability on the level of the chain. In particular, we suggest two attitudinal elements: Network Orientation and Opportunity Seeking, and two exchange rules: reciprocity and SC power, as relational antecedents for SC distinctive innovative capability. A central proposition that follows is that the cultivation of *soft* governance norms will eventually lead to *hard* innovation outcomes.

The study presented shall contribute to broadening our understanding of relational governance from a theoretical standpoint, in response to calls for research that underpins elements of this governance structure (Cousins et al., 2006; Nyaga et al., 2010). Moreover,

performing analysis on the SC level contributes to theory by responding to calls on using the RBV on the SC level, where "resources reside" (Barney and Mackey, 2005; Ketchen and Hult, 2007). Resources reside in SC networks in which firms are located, and not so much within individual firms (Gulati, 1999; Ketchen and Hult, 2007). Particularly, when it comes to "relationship research", it becomes more important to broaden the unit of analysis (Wathne and Heide, 2004).

On the practical frontier, this paper highlights the actions and attitudes that will determine SC innovation outcomes. This is very important in addressing several challenges faced by managers. Firstly, a discrepancy of outcomes from similar innovation efforts signals a need to direct attention to hidden, soft factors of influence (Devaraj et al., 2007; Patterson et al., 2004). Furthermore, managers are witnessing an upsurge in innovation performance standards. Numerous factors have been previously proposed to affect the success of joint innovation projects in SCs including trust and commitment, information sharing and integration, commonality of goals, and others, have progressed into being more of generic strategies. Adoption of these strategies has become evident in numerous firms and industries, failing to provide satisfactory competitive advantage for adopters. This has created a need to shed light on other distinguishing factors for companies pursuing sustainable competitive advantage. It is indeed time to proceed to a next stage of "distinctive" relational factors. Four are suggested herein.

The next section lays theoretical foundations for distinctive innovative capability and its significance. Section 3 describes the case methodology used to explore antecedents of distinctive innovative capability. Section 4 integrates case findings with support from SET to present the main propositions. And finally, Section 5 offers implications and concluding remarks.

THEORETICAL FOUNDATIONS OF DISTINCTIVE INNOVATIVE CAPABILITY

Supply chains undergo joint innovation efforts aiming to improve efficiency and/or effectiveness of current processes, detect and resolve problems, or develop new products. Applications of such include, but are not limited to, supplier involvement in new product development (Chung and Kim, 2003; Mendez and Pearson, 1994; Takeishi, 2001; Wynstra et al., 2001), supplier development by manufacturer (Humphreys et al., 2004; Krause et al., 2007; Modi and Mabert, 2007; Talluri et al., 2010; Watts and Hahn, 2006), and, to a lesser academic recognition, retailer involvement (Kulp et al., 2004; Parker, 2000; Stewart-Knox and Mitchell, 2003). This rest of this section presents the central argument of how (innovation) capabilities can exist on the level of the SC and how they can be distinctive. In this section we present theoretical

propositions that are not empirically deduced or tested in this study, but lay the foundations for the upcoming case research.

Distinctive Supply Chain Capabilities

The SC can be viewed as a system established for the purpose of accomplishing a system's goal (Simatupang et al., 2004; van-Hoek et al., 2001). According to the theory of constraints, this system's performance is dictated by the least performing member, i.e. "constraint", and can only be advanced if this constraint is removed by improving its performance (Davies and Brady, 2000). In line with this holistic view of the "extended enterprise", the SC becomes limited by the strength of its weakest (i.e. least performing) member. Therefore, it is imperative that stronger members work towards developing weaker ones, i.e. working for the "total" improvement, by building capabilities on the level of the whole chain.

In recognizing SCs as the evolved units of competition (Capaldo, 2007; Christopher and Ryals, 1999; Harvey, 2000; Sharifi et al., 2006; Straub et al., 2004), Ketchen and Hult (2007) suggest that unique resources may exist at the SC level, and it is those resources that may secure competitive advantage for SCs. Furthermore, given that the SC can be viewed as a network (Harland et al., 1999; Lamming et al., 2000), resources actually reside in this inter-firm network in which firms are located, and not so much within individual firms (Gulati, 1999).

Following Ketchen and Hult's (2007) argument that unique capabilities can exist on the SC level, we contend that distinctive capabilities will only exist on the level of the SC when the SC exhibits strong relational links. Verona (1999) classifies rent-generating capabilities into functional and relational/ integrative. On the firm level, the former set of capabilities (also known as operational capabilities) allows a firm to deepen its technical knowledge and is typically related to the firm's ability to design, manufacture and deliver (Lorenzoni and Lipparini, 1999; Verona, 1999). For SC competitiveness, functional capabilities are required for all firms in the chain. A functionally incompetent firm will limit the performance of the whole chain, according to the theory of constraints.

The combination of functional capabilities can be collectively effective, only if SC firms possess relational (also known as integrative or network enabled) capabilities. These relate to communication, interaction, problem resolution and relationship development among SC members (Verona, 1999). According to the relational view, distinctive capabilities may span a firm's boundaries and are jointly generated (and appropriated) with partner firms (Dyer and Singh, 1998). Relational capabilities, residing in networks and social interactions, act as facilitators for functional teams to reach their goals. The quality of group work including interactions, relationships, and collaborations will improve how knowledge sources successfully

function (Subramaniam and Youndt, 2005). This ability to interact and share knowledge with other companies is a distinctive competence on the firm level (Lorenzoni and Lipparini, 1999), and a distinctive competence within the SC level, when possessed by all chain firms (Figure 1).

P1. *Distinctive functional capabilities of SC firms will be translated into distinctive SC capabilities only if chain firms possess strong relational elements. The strength of the collective SC capability will be limited by the weakest relational link in the chain.*

Sustainable SC Advantage from Innovative Capabilities

Extending the RBV argument to the level of analysis where resources reside, SCs become the alternative rent seeking unit, aiming to sustain competitive advantage. As chain members do not all share a common organizational affiliation, the development of distinctive SC capabilities is vital to the chain's sustainable advantage (Barney, 1991; Hult et al., 2007; Lavie, 2006; Wernerfelt, 1984). Firms in a SC can achieve competitive advantage through accessing SC network resources (Lavie, 2006). As chain firms nurture relationships with partners and create synergies from SC collaboration, they also gain collaborative advantage (Huxham, 1993; Huxham and Macdonald, 1992). Within this collaborative paradigm, a SC becomes a network of interdependent relationships developed and fostered through strategic collaboration with the goal of deriving mutual benefits (Ahuja, 2000; Chen and Paulraj, 2004; Miles and Snow, 1986; Thorelli, 1986). In this regard, the pursued "sustainable advantage" implies maintaining both the strength of relationship ties and above-average profits in a chain.

P2. *Distinctive SC capabilities will lead to sustainable SC advantage. Sustainable SC advantage implies both competitive advantage and collaborative advantage for all chain firms.*
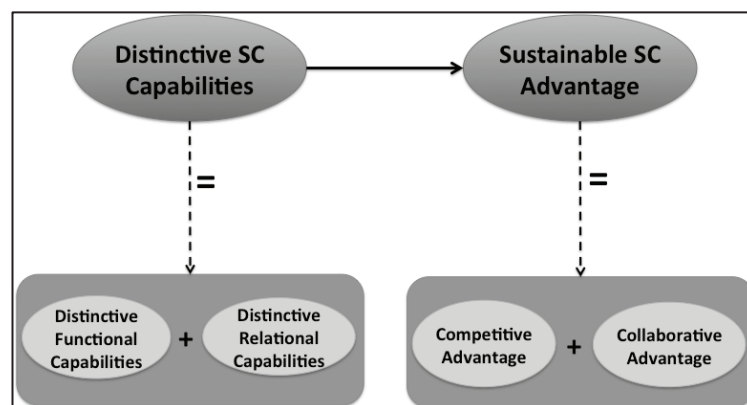

Fig. 1: RBV Applied to the SC Level

The above discussion raises an important question as to which capabilities are most relevant for sustainable SC advantage. Barratt and Oke (2007), for instance, propose distinctive SC visibility (the outcome of sharing relevant, accurate and timely information) as a capability that secures sustainable advantage for firms in a SC. In today's business era, the capability to innovate is being cited as one of the most important assets companies can develop. Innovation has evolved from being a nicety to being a necessity for both cost reduction and revenue generation. We will, therefore, emphasize innovative capabilities based on two premises: (1) the central role that innovation plays in sustaining advantage (Capaldo, 2007; Charles-Galunic and Rodan, 1998; McGrath and Ming-Hone, 1996; Olavarrieta and Ellinger, 1997; Rodan and Galunic, 2004), and, (2) significance of the network (SC) level for cultivating innovative capabilities (Eisenhardt and Schoonhoven, 1996; Panayides and Venus Lun, 2009; Rodan and Galunic, 2004; Zaheer and Bell, 2005).

A SC's ability to synchronize the innovation process leads to competitive advantage (Ireland and Webb, 2007). A firm can outsource the positive effects of innovative capability to its SC partners and still benefit (Azadegan et al., 2008). When the chain exhibits a high degree of idiosyncratic investments by its members in market valuable innovations, the chain will have acquired distinctive innovative capability. What makes the innovative capability distinctive is the quality of combined knowledge/ expertise and quality of the relationship in the chain (equivalently technical and integrative abilities). Following the argument on distinctive SC capabilities, distinctive SC innovative capability is valuable, rare, inimitable and non-substitutable.

P3. *Distinctive SC innovative capability will lead to sustainable SC advantage.*

CASE STUDY METHOD

Background and Method Justification

A case study is an objective, in-depth examination of a contemporary phenomenon where the investigator has little control over events (Yin, 1989). Three factors collectively favor the use of case research in this study. Firstly, given the complexity of investigating highly strategic factors that guide the collaborative advantage of various SCs, case-based research represents a very attractive methodology. Case research is appropriate when the objective is to capture contingent conditions and complex environment, and is especially powerful for answering the "why" question (Stuart et al., 2002).

Secondly, the literature gap and unexplained variations in long term performance of firms engaging in joint SC innovations call for theory building efforts, to which the best candidate is

case research. Finally the lack of well supported definitions and metrics regarding SC level resources and collaborative advantage points to the use of a rather qualitative and exploratory methodology. Collectively, paucity of theory, complexity, and lack of well-supported definitions and metrics favor the use of case studies (Stuart et al., 2002). To ensure rigorous application of the case method, several tactics were employed (see Table 1).

Table 1 Tactics for Case Rigor

Test	Case Study Tactic	Literature Support for Tactic Rigor
Reliability	Used case study protocol (Appendix A)	(Stuart et al., 2002; Voss et al., 2002)
	Developed case study database	(Stuart et al., 2002; Yin, 1994)
Internal validity	Pattern matching using cross-case analysis (section 4.2)	(Eisenhardt, 1989; Yin, 1989)
	Specification of unit of analysis	(Dubé and Paré, 2003; Yin, 1994)
External validity	Multiple case studies	(Eisenhardt, 1989; Eisenhardt and Graebner, 2007; Yin, 1994)
Construct validity	Chain of evidence	(Darke et al., 1998; Voss et al., 2002; Yin, 2009)

Study Focus and Unit of Analysis

The strength of the case methodology lies in its ability to bear tentative research questions and constructs. Theoretical assumptions can be kept to a minimum if cases are conducted for theory development (McCutcheon and Meredith, 1993). The academic literature, however, is still found to substantially support the suggested propositions on distinctive innovative capability (see theoretical development Section 6). The industry voice obtained from the cases is further strengthened by support from literature, primarily on SC Management and Organizational Theory. Cases are used, in conjunction with literature support, to formulate propositions (Sections 5 and 6). In case studies, we deal with only relational inference (where we attempt to determine if one factor is related to: e.g., correlated with, caused by, modified by another) because the case is not intended to represent a sample from a population (Meredith, 1998). For statistical inference, future empirical testing (e.g. using survey methodology) can be employed.

The initial research questions can be stated as: (1) Why do different SCs exhibit varying degrees of sustainable collaborative advantage from joint innovation projects; and, (2) if the concept of distinctive innovative capability can be used to explain these discrepancies, what are

its relational antecedents? As previous studies have been repeatedly criticized for lack of clarity on units of analysis (Subramanian and Nilakanta, 1996; Wolfe, 1994), clear specification of the analysis level is a basic building block for rigorous case research (Dubé and Paré, 2003; Markus, 1989; Yin, 1989) (See Table 1). In this research, each firm is treated as a case, based on the respondent's perceptions on SC partner relationships. Voss et al. (2002) suggest that "a case study is a unit of analysis in case research" adding that it is possible to "research the same issue in a *variety* of contexts in the *same* firm". Each case (firm) can provide the opportunity to study several linkages within the case (Mukherjee et al., 2000). A study of a single firm may involve a number of different SC linkages (Voss et al., 2002). Nevertheless, the SC linkage unit of analysis is clearly reflected in the (tentative) construct definitions and the interview protocol used to collect data (See Appendix A).

Case Sampling

Contrary to other empirical methodologies, biased (deliberate) sampling is widely accepted in case research. Three sampling issues are carefully considered in this research. Firstly, as the phenomenon studied (distinctive innovative capability) has little theoretical background, an exemplar site, which is a large automotive manufacturer (TMTV1), is selected to provide close-to-best example of that phenomenon (Yin, 1989). This manufacturer is perceived to have sustainable *SC* advantage, in conjunction with several of its suppliers. The ranges of relationships with different suppliers can show the varying levels of proposed antecedents and their effect on joint performance. Secondly, because multiple cases are highly recommended for external validity (Table 1), robustness and theory testability (Eisenhardt, 1989; Eisenhardt and Graebner, 2007; Yin, 1994), the exemplar case will be followed with three more studies across different industries.

A general invitation email summarizing the purpose of the study, and time and information required from respondents was sent to subject matter experts (through LinkedIn). Interested respondents replied to set up interviews. The companies represented: another automotive producer (TMTV2), a large cement manufacturer (CMNT), and a parts supplier (PTSUP) (respondent titles are shown in Table 2). Thirdly, because the phenomenon of interest relates to success or failure in achieving distinctive innovative capability, retrospective cases are used. Retrospective cases allow for more controlled case selection, by asking respondents about those instances, as it becomes easier to identify cases that reflect either success or failure only in retrospect (Chris et al., 2002). The collective sample of four firms exhibits reasonable ranges of (tentative) independent variables we are most confident will impact the dependent variable (distinctive innovative capability). Eisenhardt (1989) strongly suggested four to ten cases, arguing that if less than four it may become difficult to capture the complexity of the real world and if more than ten it may become difficult for the researchers to cognitively process the information.

Table 2 Case Firms and Respondents' Titles

Company	Respondent Title
TMTV1	Supplier Technical Assistance Resident
TMTV2	Former Logistics Manager
CMNT	Vice-President & General Manager
	Former Director of Distribution Strategy
PTSUP	Former Materials & Logistics Manager

Data Collection

The data source used was semi-structured interviews. Prepared questions were used merely to guide the interview conversations, but respondents were generously given the chance to give examples, elaborate on issues they thought as important or introduce factors that have not been mentioned in the interview. The protocol serves as a prompt for the interview and as a checklist to make sure that all topics have been covered (Chris et al., 2002). It also enhances reliability and case rigor (Table 1). An agenda summarizing points to be discussed was sent by email to respondents willing to participate. As dates were set for interviews, the common funnel model was used in the conducted interviews (See Appendix A for interview protocol). This format starts with broad and open-ended questions first, and as the interview progresses the questions become more specific and the detailed questions come last (Chris et al., 2002). In multi-case research, a well-designed protocol is particularly important (Chris et al., 2002).

Interview duration average was around 90 minutes. Three interviews were used for the exemplar case (TMTV1) and one or two for the rest of the cases. As face-to face meetings are usually preferred when possible, this was stated in the invitation email, clarifying that phone could be used according to respondent's convenience. For the exemplar case in person meetings were conducted, while the rest preferred phone interviews.

DATA ORGANIZATION AND ANALYSIS

The biggest challenge behind data analysis is to demonstrate the objectivity of the process through which the data and field notes are developed into conclusions (Barratt et al., 2011; Eisenhardt, 1989; Miles and Huberman, 1984). Our analysis focused on varying long run innovative outcomes from joint SC projects, antecedents of distinctive innovative capability, its levels, and its potential to achieve sustainable advantage for different linkages. In each case, similar factors start emerging as antecedents for varying innovative performance. Results from within case analysis are discussed below, and summarized in Table 3.

Within Case Analysis

Case I: The automotive firm TMTV1

TMTV1 has a huge supplier base (more than 5000 suppliers) that comprises the contexts studied in this case. The firm engages in numerous SC innovation projects with many of those suppliers. Engagement, however, varies in extent from deep joint involvement (supplier development efforts and supplier involvement in new product development), to simple problem solving aids. Technologies can also be propagated through third party providers, which take technologies to different players in the chain. Moreover, these projects also range from being formally mandated, i.e. through contracts, to being very informally suggested. TMTV1 has a list of "top" suppliers with which involvement is generally more intense, takes various forms and entails more knowledge exchange. The rest are still closely managed, but with considerable less degree. Joint innovation projects with top suppliers generally exhibit higher success rates.

The company regards its SC as its extended enterprise, making sure that everything goes well with those suppliers. TMTV1 strictly makes sure that all of its suppliers' financial performance is regularly healthy and that they are making profits. When TMTV1 mandates use of a certain technology/ method or process for its own enhanced performance, the suppliers are paid back through TMTV1's commitment to repeated business. Moreover, both TMTV1 and its top suppliers make investments at each other's plants to educate, train, implement or design new products and processes. These investments lead to more innovative partners. When resources circulate, the whole SC becomes better.

TMTV1 has recently implemented an initiative with top suppliers, in which the company pays regular, unscheduled visits, going to their facilities, looking at priority operating systems and detailed jobs to evaluate performance. They could even give suppliers specific assignments to be carried out within schedule. TMTV1 asserts that the methods conveyed to suppliers (especially incremental improvements) are extremely difficult to patent. The company, therefore, depends on its suppliers' willingness for repeated (sustainable) business that drives those suppliers to protect TMTV1's knowledge.

Conversely, with non-top suppliers TMTV1 uses its bargaining power to mandate certain technologies or processes (ex SPC). "To be able to do business with us, they have to learn it on their own and implement it. They may or may not succeed".

Case II: Cement Firm: CMNT

Innovation in the cement industry is vital for developing lighter weight and more flexible products that meet more needs. The company started rethinking its business model to capture opportunities in the SC. Because the primary focus was previously solely on the product, huge opportunities existed for innovation on transportation, warehousing and logistics. For example,

on a safety front, CMNT management started thinking how the delivery process was going and how they can improve on the safety. They started discussing with truckers and sharing the best ideas with carriers. For example, how a trailer is decompressed, whether a trailer is idled or turned on, how to set the proper procedure to get up on trailer or out of trailer to avoid injury, and how to fix practices to assure the integrity of the product. By investing the time and effort with those carriers, they have become more innovative (one successful outcome was capping cement hoses at both ends, which used to be open before; this helped to prevent the product from getting contaminated from the atmosphere). Ultimately, both CMNT and the carrier benefit in terms of innovation performance from each other's ideas.

The company continuously educates many of its suppliers on how to perform quality control, what the important aspects of their products are and how to improve on those aspects. This saves considerable effort from suppliers' side and helps the buyer (CMNT) get innovative outcomes faster and more effectively.

Even though CMNT realizes risks from knowledge leaking to competitors, the company is still willing to invest in suppliers' innovations. The company gives up the short sighted view of "confine knowledge to protect against short term competition" to a longer term, more global view of "it is fair that our suppliers sell to others (even if using knowledge gained from CMNT); we still have to help them as we need to perfect those products supplied to us". In fact, the company believes that the current dynamic competition is mostly time based, which means that by the time competitors imitate, CMNT would already be in the next generation of innovations. Even though confidentiality agreements are signed, the real protection depends on the strength and depth of relationships.

CMNT is inclined to maximize the total SC performance. The company, for example, built storage units on its supplier's site; where the supplier places containers in those storage units and CMNT pays for it. The aim is to minimize total movement and cost, not to overload one partner with costs. Even though CMNT is a technology leader and has high bargaining power, this lead is positively used to drive innovativeness and maximize global performance.

Case III: The Automotive Firm II: TMTV2

TMTV2 suffered from an unsuccessful involvement relationship with one of its suppliers. Selecting the supplier for political and cost considerations only, technical competence really suffered. The supplier was unable to fulfill contractual obligations (on process standards). This mainly stemmed from the fact that the supplier was not making satisfactory profits by dealing with the automotive manufacturer. Even though TMTV2 tried to help and support the supplier to implement its process requirements, it got involved too early, which signaled a competence problem in the supplier's plants. From TMTV2's perspective, the company selected suppliers,

set process requirements and even provided aid based on its (perceived) individual welfare. A global perspective would have suggested selection based on competence to better allocate aid resources and produce a competitive product. Moreover, the focus from this joint project was confined on merely getting the specific process to work as required, not to start a true collaborative relationship for pursuing future opportunities. Eventually, partners suffered from trust issues and knowledge leaking to competition. The project was, eventually, discontinued.

Case IV: Part Supplier: PTSUP

PTSUP works very closely with most of its suppliers, realizing the importance of sharing information and integrating operations. When the company starts a project, it provides the supplier with the target (specification) and restrictions (design and price) and gives the supplier as much information as needed. At this (primary) stage, the company lets the supplier decide on how to achieve the required target with no interference. Involvement takes place, however, only if the supplier is unable to deliver goods/ services within the time frame and cost agreed upon. In this case (reactive), PTSUP would hold meetings and pay visits to supplier plants helping to solve the problem.

Even though the PTSUP's suppliers are continuously involved in its innovations, bringing in much more than goods and services, i.e. ideas, this does not happen in the reverse direction. Even though PTSUP believes that it can always add to its suppliers operations and performance, it has not yet implemented a policy of continuous monitoring and evaluation of suppliers. The result is running into long term deals with suppliers that suffer from financial performance, or missing several enhancement opportunities. Proactive initiatives with suppliers would have prevented several problems and would have created more opportunities.

One example of sharing innovations was a vertically integrated storage unit system, which the company also integrated with SAP. The system was a major success, allowing real time operations as SAP communicates to the vertically integrated units, distribute and supply products to workers who can deliver those products to the door. PTSUP shared the idea of this successful tool with a supplier (similar bargaining power), to enhance their delivery performance (and SC lead time). Yet, as there was no obligation on the supplier's side to abide by the technology, inertia prevented them from adopting the idea.

Cross Case Analysis

Looking further at the four cases studied, similar factors emerge as antecedents for distinctive enhancement of innovativeness. Firstly, companies relating incidents of success seem to care most about partner's performance, profitability and welfare out of those projects. These companies recognize the interdependence among partners in a SC and the need to work together towards the global goal. Their main concern became long-term capability enhancement as

opposed to short-term knowledge confinement. Time based competition is especially significant in those cases. This constitutes our first proposed factor: Network Orientation.

According to Jeffrey and Soonhong (2001), Network Orientation (NO) is a philosophy focusing on the integration of inter-organizational teams working for a goal of delivering superior customer value while sharing risks and resources to combat competition. The coordinated activities, in this case for knowledge creation, are based on notions of complementarity, interdependence and cooperative norms for the success of the SC as a whole (Jeffrey and Soonhong, 2001). Network oriented firms in a SC linkage work as a single entity of competition and maintain highly integrated functions and common goals. This emphasizes closer ties, trust and commitment. NO of linkage firms will, therefore, help achieve distinctive SC innovative capability:

P4. *NO is positively related to SC distinctive innovative capability.*

Secondly, the attitude of coming into a joint project also represents significant differences between successful and less successful projects. The former exhibit a more open attitude, viewing the current project merely as a seed for further possibilities of collaboration. These companies would start spotting viable opportunities for exploiting the joint project or for creating future enhancement projects. They make use of the interaction to gather more ideas and perfect operations on several fronts, not being restricted to the current one. More successful companies have, indeed, showed a significant level of "Opportunity Seeking" behavior from active SC innovation projects.

Looking for opportunities from collaboration is far different from simply meeting the specified requirements (Clark, 1989). Opportunity Seeking attitude relates to a key feature of human actors who are the essence of relationships and ties. Human agents have the capacity to foresee, look ahead, and reposition (Williamson, 1991). Apart from improving development project performance in terms of effectiveness and efficiency, firms may have further interest in future projects. Moreover, existing innovations can be interpreted and used in different ways by different actors (Pentland, 1992; Subramani, 2004). It, therefore, becomes important how a particular linkage intends to use a technology or an innovation and how much they can appropriate out of it. The further linkage companies dig into multiple uses from a technology or innovation, the higher their opportunity seeking behavior.

Opportunity-seeking attitude of firms allows for their relationship to be more *linkage-specific* i.e. rare. In this case, unique opportunities for both exploitation and exploration are recognized and pursued, driving competition further away and providing the needed protection from imitation. Innovations are exploited in ways different from other firms that have adopted

them, new ideas are created, and future opportunities are sought. Companies in a linkage strive to fully utilize the capabilities of a technology in their specific business setting, further advancing the value of past investments (Gunasekaran and Ngai, 2004). They would also look for unique possibilities and new business opportunities (Gunasekaran and Ngai, 2004). Therefore,

P5. *Opportunity Seeking attitude is positively related to SC distinctive innovative capability.*

A third observation, based on the cases, relates to the apparent exchange of resources and secrecy for developing and protecting the other. Successful relationships that really lead to ongoing improvements and innovations involve the willingness and ability to develop the other partner and build trust through protecting the partner's knowledge. On one hand, the partners would invest in each other's plants, without direct, contractual or immediate return. On another hand, these companies realize the limitations of confidentiality agreements, even though some still use them, and depend more on "willingness for repeated business". This willingness drives each linkage firm not only to cross invest in the partner, but also to protect the other's knowledge for both making sure the other remains competitive and cultivating trust for future collaborations. This "reciprocity" implies that a company would invest resources and efforts for outcomes going directly to its partner.

The "Social Exchange Theory" (SET) provides rules and norms that act as guidelines for exchange processes based on interdependence, and, therefore, offers a number of valuable insights to explain and understand reciprocity in SC relationships. Reciprocity or repayment in kind is one of the most common and best-known exchange rules (Cropanzano and Mitchell, 2005). According to the SET, reciprocity refers to the "voluntary actions of individuals that are motivated by the returns they are expected to bring and typically do in fact bring from others" (Blau, 1964). In reciprocal exchanges, uncertainties surround the outcomes of an exchange, as partners are not obligated to return voluntary "gifts" (Rice & Cook, 2006). This relative lack of certainty leads actors to develop feelings of trust and other positive affective orientations toward their partners as successful exchange relations emerge (Rice & Cook, 2006).

Reciprocity implies the willingness of each linkage firm to work for the other's welfare. In Economic terms it means that the direct output of one firm's actions goes to its partner. Based on reciprocity, SCs with distinctive innovative capability will, not only trust each other, but also actively act for immediate benefit of the partner, and long-term benefit of the chain.

P6. *Reciprocity is positively related to SC distinctive innovative capability.*

Finally, it was quite remarkable that some innovation opportunities were not conducted for lack of compulsion. It is mainly bargaining power that allows a company to mandate a certain technology/ improvement. Even though this can act as a significant driver for companies that would not have otherwise innovated, this power can also act as a double-edged sword. If the more powerful party mandates innovation for its individual welfare, disregarding its partner's abilities and wellbeing, the less powerful partner could be pushed out of business for inability to comply. Higher power parties must provide education, training and all the support for the less powerful, making sure that the latter profit from the venture. Accordingly, it became evident that "Power Imbalance" does affect innovative capability positively; with the relationship being conditional on two factors: the degree of Network Orientation (or equivalently lack of opportunism) and degree of reciprocity (how much aids and support are cross invested).

Theories often explain the detrimental relational effects of inter-organizational power but ignore its positive effects on relationships (Ireland and Webb, 2007). Here we argue that effect of power imbalance is positive under two conditions: (1) network orientation (i.e. non-opportunistic behavior); and, (2) reciprocity. The powerful SC partner must exercise its power advantage in an "overall value adding" way, i.e. to motivate and drive overall innovativeness and not to opportunistically obtain unequal benefits. The power game must not be exploited (Simatupang et al., 2004). A sustaining SC partners relationship cannot be possible without tangible benefits accrued to both partners (Kim, 2000). This means that the network profit attained through the coordination must be larger than the sum of uncoordinated individual profits (Kim, 2000).

In addition to overcoming opportunism, the effect of power imbalance on innovativeness is also contingent upon the extent of active support that the more powerful party provides to the other. Power can be used in a positive way to motivate and drive partners to innovate without depriving them from a fair share of return and/ or support. Threatening to pull its orders from non-complying companies, Wal-mart accompanied this move with a pledge to work with its (top) suppliers to teach them and help them improve their operations (Aston, 2009). These actions are based on high levels of trust, which builds these norms of reciprocity. Norms of reciprocity are characterized by open rather than simultaneous commitments, where a firm may never collect fully on previous exchanges (Ireland and Webb, 2007). Summary of within-case and cross-case analysis is shown in Table 3. The effect of the four suggested factors is shown in Figure 2 below.

P7a. *Power imbalance is positively related to SC distinctive innovative capability.*
P7b. *The relationship between power imbalance and SC distinctive innovative capability is positively moderated by the degree of network orientation.*

P7c. *The relationship between power imbalance and SC distinctive innovative capability is positively moderated by the degree of reciprocity.*

DISCUSSIONS AND CONCLUSIONS

For over 30 years, SC companies are increasingly responding to calls for trust, commitment, communication and collaboration. The increasing adoption of these concepts, however, made them progress into more of generic strategies that competitive ones. This has created a need to find distinguishing factors that help achieve competitive advantage for superior chains. The aim of this research is to highlight specific relational elements that can play prominent role in collective innovative performance of SCs. Findings reveal the importance of: Network Orientation, Opportunity Seeking, Reciprocity and Power Imbalance as antecedents to distinctive innovative capability, and assert that the latter is a valuable, rare, inimitable and non-substitutable capability.

We define and characterize supply chain distinctive innovative capability as a high, effective and speedy ability of a competing supply chain to produce innovations. Its VRIN properties imply sustainable advantages for chains that possess it. We proceed to practically ground this theory by using four case studies to highlight the significance of four relational elements in achieving this level of capability. The first, Network Orientation, ensures the presence of long-term orientation and positive sum game in SC partnerships. The second, Opportunity Seeking, emphasizes the importance of exploiting existing projects and relations to create further opportunities, without necessarily being confined to preset goals. The third element, reciprocity, encourages payments in kind to fill partner capability gaps, not for immediate or promised returns, but in expectation of future reciprocation. Finally, we argue that inter-firm power can push innovations through chains, and help overcome inertia, only when the powerful firm exerts partner development efforts and refrains from opportunism.
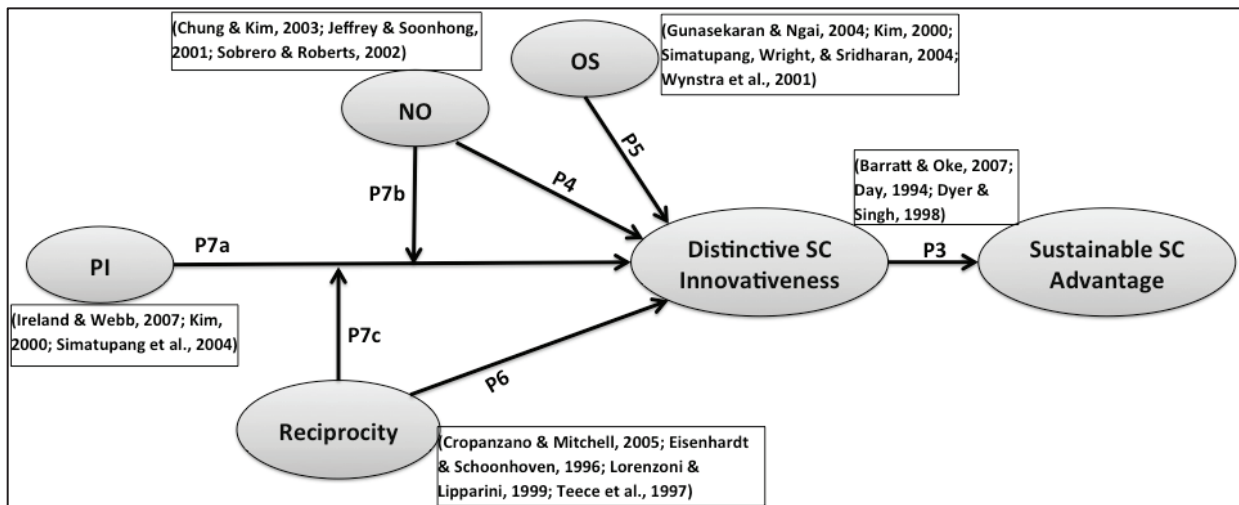
Fig. 2: Antecedents of Distinctive Innovative Capability

On the practical and managerial side, this research can help companies and policy makers on two fronts. First, as little has been known on why some SCs perform well while others do not (Christopher et al., 2004), this research sheds light on the rather neglected attitudinal factors and exchange rules that employ an increasing importance in SC management. Partners with high functional capabilities suffer from low joint performance, even though knowledge elements are all in place. It is the "relational stress" that largely limits the propagation of innovations in SCs and chains' overall capabilities (Henke and Zhang, 2010).

Secondly, power difference, traditionally perceived as negative, can in fact be used to lead and coordinate (Kumar et al., 1998). As the distribution of power has become legitimate over time, it now provides effective means for collaboration (Caniëls and Gelderman, 2007). Power difference allows the emergence of a network leader that helps innovations to propagate and gives direction for new innovations development. Collectively, the factors emphasized in this part of the research shall help companies in the long-term sustainability of above-average profits. This will result in companies being better able to allocate their resources toward innovation, providing them with an ex ante expectation of the productivity improvement of the total enterprise.

The theory developed in this paper can be extended along several dimensions. Firstly, empirical testing of the propositions suggested herein would give a stronger argument of whether those relationships hold. On another frontier, other SC capabilities can be studied in depth, exploring both their antecedents and effects on SC outcomes. Moreover, relational factors advocated in this study need more research to better understand the way they affect outcomes. Power, for instance, comes from several sources (e.g., expert power) and can be demonstrated in

different ways (reward or coercion). Power sources and demonstration methods can differently affect innovative, and other, capabilities in supply chains. Similarly, reciprocity can be positive (returning good acts) or negative (returning bad acts). The way in which these affect the collective ability of a chain to innovate is also worth studying. Finally, the way in which firms can exploit current abilities, technologies and innovations in future opportunities is also ripe for more research.

Table 3 Case Analysis Summary

Case	Attitudinal Elements		Exchange Rules		Perceived Joint innovative Performance
	Network Orientation	Opportunity Seeking	Reciprocity	Power Imbalance	
TMTV1	Regularly checks financial health of top suppliers and evaluates their general performance	Pays unscheduled visits to suppliers, trying to spot areas of improvements. Gets visits from suppliers and encourage their input in improving its processes.	Circulation of human resource in cross education & training. Willingness of repeated business ensures cross protection of knowledge.	Mandates propagation of technologies based on their technological lead.	High and distinctive
CMNT	Takes initiatives for improvements seen to be in the benefit of the whole chain (e.g. building and paying for supplier storage units)	Continuous exchange of ideas for future improvements. Carriers provide CMNT with ideas to improve safety. CMNT provides suppliers with ideas on what aspects of products to improve.	Relationship strength and depth acts as the real protection against knowledge leakage, more than signed agreements.	Enjoys higher power relative to suppliers, but not necessarily used in mandating	High
TMTV2	Set requirements for suppliers and let them do it.	Work on a project-by-project basis	We mainly depend on confidentiality agreements for protecting our knowledge, but still observe leakage to competitors	Use power to mandate without necessarily providing aids or watching suppliers' performance	Not satisfactory
PTSUP	Pay little attention to performance of suppliers	Take mostly a reactive approach to problem solving, rarely think of creating new opportunities	We develop our suppliers mainly in reacting to quality (or other) problems	No significant power difference makes inertia mostly overcome propagation of ideas	Below expected

APPENDICES

Appendix A
Interview Protocol

Defining:

* *Distinctive innovative capability*: as exceptionally high compared to competitors, leading to future rents

* *Joint innovation project*: Any innovation including inter-organizational system, software or practice that was jointly developed or implemented with a buyer/ supplier firm or otherwise induced to develop or implement by a buyer or supplier firm.

- Considering instances of cooperative innovation projects with suppliers (alternatively OEM's/ customers), what are some instances that you can describe as distinctively successful?
- What are the outcomes of the cooperative innovation projects? (relational assets? Innovativeness? Profitability)?
- What are some of the ways in which the joint projects were distinctively innovative?
  - o Your and your partner's innovative capability significantly enhanced?
  - o Was your resulting capability distinct from competitors?
  - o Was the capability valuable for future projects?
  - o Was the capability not easily imitated by competitors and not easily substituted?
- For each of the mentioned instances, what are some of the reasons why you think the project was distinctively successful?
- How mandated/ formal was the cooperative relationship?
- How does the degree of obligation affect the outcomes/ efforts/ motivation?
- What type of knowledge do suppliers/ customers have for each other?
- When is knowledge transferred to partner? Are initiatives readily taken or only in response to problems?
- Considering other less successful instances of cooperative projects with suppliers/ customers, what are some of the reasons why you think they were not or did not lead to distinctive innovative capability?

REFERENCES

1. Adner, R. (2006) "Match Your Innovation Strategy To Your Innovation Ecosystem", *Harvard Business Review,* 84(4), 98-107.
2. Ahuja, G. (2000) "The Duality Of Collaboration: Inducements And Opportunities In The Formation Of Inter-Firm Linkages", *Strategic Management Journal,* 21(3), 317.

3. Aston, A. (2009) "Wal-Mart: Making Its Suppliers Go Green", *Business Week* [Online], Available: Http://Www.Businessweek.Com/Magazine/Content/09_21/B4132044814736.Htm?Chan=Magazine+Channel_In+Depth
4. Azadegan, A., Dooley, K. J., Carter, P. L. And Carter, J. R. (2008) "Supplier Innovativeness And The Role Of Interorganizational Learning In Enhancing Manufacturer Capabilities", *Journal Of Supply Chain Management,* 44(4).
5. Barney, J. (1991) "Firm Resources And Sustained Competitive Advantage", *Journal Of Management,* 17(1), 99-120.
6. Barney, J. B. And Mackey, T. B. (2005) "Testing Resource-Based Theory", *Research Methodology In Strategy And Management,* (2), 1-13.
7. Barratt, M., Choi, T. Y. And Li, M. (2011) "Qualitative Case Studies In Operations Management: Trends, Research Outcomes, And Future Research Implications", *Journal Of Operations Management,* 29(4), 329-342.
8. Blau, P. M. (1964) *Exchange And Power In Social Life,* Transaction Publishers.
9. Caniëls, M. C. J. And Gelderman, C. J. (2007) "Power And Interdependence In Buyer Supplier Relationships: A Purchasing Portfolio Approach", *Industrial Marketing Management,* 36(2), 219-229.
10. Capaldo, A. (2007) "Network Structure And Innovation: The Leveraging Of A Dual Network As A Distinctive Relational Capability", *Strategic Management Journal,* 28(6), 585-608.
11. Cash, J. J. I., Earl, M. J. And Morison, R. (2008) "Teaming Up To Crack Innovation & Enterprise Integration", *Harvard Business Review,* 86(11), 90-100.
12. Charles-Galunic, D. And Rodan, S. (1998) "Resource Recombinations In The Firm: Knowledge Structures And The Potential For Schumpeterian Innovation", *Strategic Management Journal,* 19(12), 1193-1201.
13. Chen, I. J. And Paulraj, A. (2004) "Understanding Supply Chain Management: Critical Research And A Theoretical Framework", *International Journal Of Production Research,* 42(1), 131-163.
14. Chris, V., Nikos, T. And Mark, F. (2002) "Case Research In Operations Management", *International Journal Of Operations & Production Management,* 22(2), 195.

15. Christopher, L. S., David, J. K., Jr., Hult, G. T. M. And Kacmar, K. M. (2004) "An Assessment Of The Use Of Structural Equation Modeling In Strategic Management Research", *Strategic Management Journal,* 25(4), 397.

16. Christopher, M. And Ryals, L. (1999) "Supply Chain Strategy: Its Impact On Shareholder Value", *International Journal Of Logistics Management, The,* 10(1), 1-10.

17. Chung, S. A. And Kim, G. M. (2003) "Performance Effects Of Partnership Between Manufacturers And Suppliers For New Product Development: The Supplier"S Standpoint", *Research Policy,* 32(4), 587-603.

18. Clark, K. B. (1989) "Project Scope And Project Performance: The Effect Of Parts Strategy And Supplier Involvement On Product Development", *Management Science,* 35(10), 1247-1263.

19. Cousins, P. D., Handfield, R. B., Lawson, B. And Petersen, K. J. (2006) "Creating Supply Chain Relational Capital: The Impact Of Formal And Informal Socialization Processes", *Journal Of Operations Management,* 24(6), 851-863.

20. Cropanzano, R. And Mitchell, M. (2005) "Social Exchange Theory: An Interdisciplinary Review", *Journal Of Management,* 31(6), 874-900.

21. Darke, P., Shanks, G. And Broadbent, M. (1998) "Successfully Completing Case Study Research: Combining Rigour, Relevance And Pragmatism", *Information Systems Journal,* 8(4), 273-289.

22. Davies, A. And Brady, T. (2000) "Organizational Capabilities And Learning In Complex Product Systems: Towards Repeatable Solutions", *Research Policy,* 29(7-8), 931-953.

23. Devaraj, S., Krajewski, L. And Wei, J. C. (2007) "Impact Of Ebusiness Technologies On Operational Performance: The Role Of Production Information Integration In The Supply Chain", *Journal Of Operations Management,* 25(6), 1199-1216.

24. Dooley, L. And O"Sullivan, D. (2007) "Managing Within Distributed Innovation Networks", *International Journal Of Innovation Management,* 11(3), 397-416.

25. Dubé, L. And Paré, G. (2003) "Rigor In Information Systems Positivist Case Research: Current Practices, Trends, And Recommendations", *MIS Quarterly,* 27(4), 597-635.

26. Dwyer, F. R., Schurr, P. H. And Oh, S. (1987) "Developing Buyer-Seller Relationships", *Journal Of Marketing,* 51(2), 11-27.

27. Dyer, J. H. And Singh, H. (1998) "The Relational View: Cooperative Strategy And Sources Of Interorganizational Competitive Advantage", *The Academy Of Management Review,* 23(4), 660-679.

28. Eisenhardt, K. M. (1989) "Building Theories From Case Study Research", *The Academy Of Management Review,* 14(4), 532-550.

29. Eisenhardt, K. M. And Graebner, M. E. (2007) "Theory Building From Cases: Opportunities And Challenges", *Academy Of Management Journal,* 50(1), 25-32.

30. Eisenhardt, K. M. And Schoonhoven, C. B. (1996) "Resource-Based View Of Strategic Alliance Formation: Strategic And Social Effects In Entrepreneurial Firms", *Organization Science,* 7(2), 136-150.

31. Griffith, D. A. And Myers, M. B. (2005) "The Performance Implications Of Strategic Fit Of Relational Norm Governance Strategies In Global Supply Chain Relationships", *Journal Of International Business Studies,* 36(3), 254-269.

32. Gulati, R. (1999) "Network Location And Learning: The Influence Of Network Resources And Firm Capabilities On", *Strategic Management Journal,* 20(5), 397.

33. Gunasekaran, A. And Ngai, E. (2004) "Information Systems In Supply Chain Integration And Management", *European Journal Of Operational Research,* 159(2), 269-295.

34. Harland, C. M., Lamming, R. C. And Cousins, P. D. (1999) "Developing The Concept Of Supply Strategy", *International Journal Of Operations & Production Management,* 19(7), 650-674.

35. Harvey, M. (2000) "Innovation And Competition In UK Supermarkets", *Supply Chain Management: An International Journal,* 5(1), 15-21.

36. Henke, J. W. And Zhang, C. (2010) "Increasing Supplier-Driven Innovation", *MIT Sloan Management Review,* 51(2), 41-46.

37. Hult, G. T. M., Ketchen, D. J. And Arrfelt, M. (2007) "Strategic Supply Chain Management: Improving Performance Through A Culture Of Competitiveness And Knowledge Development", *Strategic Management Journal,* 28(10), 1035-1052.

38. Humphreys, P. K., Li, W. L. And Chan, L. Y. (2004) "The Impact Of Supplier Development On Buyer–Supplier Performance", *Omega,* 32(2), 131-143.

39. Huxham, C. (1993) "Pursuing Collaborative Advantage", *Journal Of The Operational Research Society,* 44(6), 599-611.

40. Huxham, C. And Macdonald, D. (1992) "Introducing Collaborative Advantage: Achieving Interorganizational Effectiveness Through Meta-Strategy", *Management Decision,* 30(3), 50-56.

41. Ireland, R. D. And Webb, J. W. (2007) "A Multi-Theoretic Perspective On Trust And Power In Strategic Supply Chains", *Journal Of Operations Management,* 25(2), 482-497.

42. Jeffrey, W. O. And Soonhong, M. (2001) "International Supply Chain Management In An Internet Environment: A Network-Oriented Approach To Internationalization", *International Marketing Review,* 18(4), 392.

43. Ketchen, D. J. And Hult, G. T. M. (2007) "Bridging Organization Theory And Supply Chain Management: The Case Of Best Value Supply Chains", *Journal Of Operations Management,* 25(2), 573-580.

44. Kim, B. (2000) "Coordinating An Innovation In Supply Chain Management", *European Journal Of Operational Research,* 123(3), 568-584.

45. Krause, D. R., Handfield, R. B. And Tyler, B. B. (2007) "The Relationships Between Supplier Development, Commitment, Social Capital Accumulation And Performance Improvement", *Journal Of Operations Management,* 25(2), 528-545.

46. Kulp, S. C., Lee, H. L. And Ofek, E. (2004) "Manufacturer Benefits From Information Integration With Retail Customers", *Management Science*, 431-444.

47. Kumar, N., Scheer, L. K. And Steenkamp, J.-B. E. M. (1998) "Interdependence, Punitive Capability, And The Reciprocation Of Punitive Actions In Channel Relationships", *Journal Of Marketing Research (JMR),* 35(2), 225-235.

48. Lamming, R., Johnsen, T., Zheng, J. And Harland, C. (2000) "An Initial Classification Of Supply Networks", *International Journal Of Operations & Production Management,* 20(6), 675-691.

49. Lavie, D. (2006) "The Competitive Advantage Of Interconnected Firms: An Extension Of The Resource-Based View", *Academy Of Management Review,* 31(3), 638-658.

50. Lorenzoni, G. And Lipparini, A. (1999) "The Leveraging Of Interfirm Relationships As A Distinctive Organizational Capability: A Longitudinal Study", *Strategic Management Journal,* 20(4), 317.

51. Markus, M. L. (1989) "Case Selection In A Disconfirmatory Case Study" In Cash, J. I. And Lawrence, P. R., Eds., *The Information Systems Research Challenge: Qualitative Research Methods*, Boston: Harvard Business School Press, 20–26.

52. Mccutcheon, D. M. And Meredith, J. R. (1993) "Conducting Case Study Research In Operations Management", *Journal Of Operations Management,* 11(3), 239-256.

53. Mcgrath, R. G. And Ming-Hone, T. (1996) "Innovation, Competitive Advantage And Rent: A Model And Test", *Management Science,* 42(3), 389-403.

54. Mendez, E. G. And Pearson, J. N. (1994) "Purchasing"S Role In Product Development: The Case For Time Based Strategies", *Journal Of Supply Chain Management,* 30(1), 2-12.

55. Meredith, J. (1998) "Building Operations Management Theory Through Case And Field Research", *Journal Of Operations Management,* 16(4), 441-454.

56. Miles, M. B. And Huberman, A. M. (1984) *Qualitative Data Analysis,* Beverly Hills, CA: Sage Publications.

57. Miles, R. E. And Snow, C. C. (1986) "Organizations: New Concepts For New Forms", *California Management Review,* 28(3), 62-73.

58. Modi, S. B. And Mabert, V. A. (2007) "Supplier Development: Improving Supplier Performance Through Knowledge Transfer", *Journal Of Operations Management,* 25(1), 42-64.

59. Mukherjee, A., Mitchell, W. And Talbot, F. B. (2000) "The Impact Of New Manufacturing Requirements On Production Line Productivity And Quality At A Focused Factory", *Journal Of Operations Management,* 18(2), 139-168.

60. Nyaga, G. N., Whipple, J. M. And Lynch, D. F. (2010) "Examining Supply Chain Relationships: Do Buyer And Supplier Perspectives On Collaborative Relationships Differ?", *Journal Of Operations Management,* 28(2), 101-114.

61. Olavarrieta, S. And Ellinger, A. E. (1997) "Resource-Based Theory And Strategic Logistics Research", *International Journal Of Physical Distribution & Logistics Management,* 27(9/10), 559-587.

62. Panayides, P. M. And Venus Lun, Y. H. (2009) "The Impact Of Trust On Innovativeness And Supply Chain Performance", *International Journal Of Production Economics,* 122(1), 35-46.

63. Parker, H. (2000) "Interfirm Collaboration And The New Product Development Process", *Industrial Management & Data Systems,* 100(6), 255-260.

64. Patnayakuni, R., Rai, A. And Seth, N. (2006) "Relational Antecedents Of Information Flow Integration For Supply Chain Coordination", *Journal Of Management Information Systems,* 23(1), 13-49.

65. Patterson, K. A., Grimm, C. M. And Corsi, T. M. (2004) "Diffusion Of Supply Chain Technologies", *Transportation Journal,* 43(3), 5-23.

66. Pentland, B. T. (1992) "Organizing Moves In Software Support Hot Lines", *Administrative Science Quarterly,* 37(4), 527-548.

67. Porter, M. E. And Kramer, M. R. (2011) "Creating Shared Value", *Harvard Business Review,* 89(1/2), 62-77.

68. Rodan, S. And Galunic, C. (2004) "More Than Network Structure: How Knowledge Heterogeneity Influences Managerial Performance And Innovativeness", *Strategic Management Journal,* 25(6), 541-562.

69. Sharifi, H., Ismail, H. S. And Reid, I. (2006) "Achieving Agility In Supply Chain Through Simultaneous "Design Of" And "Design For" Supply Chain: IMS", *Journal Of Manufacturing Technology Management,* 17(8), 1078-1098.

70. Simatupang, T. M., Wright, A. C. And Sridharan, R. (2004) "Applying The Theory Of Constraints To Supply Chain Collaboration", *Supply Chain Management: An International Journal,* 9(1), 57-70.

71. Snow, C. C. And Hrebiniak, L. G. (1980) "Strategy, Distinctive Competence, And Organizational Performance", *Administrative Science Quarterly,* 25(2), 317-336.

72. Stewart-Knox, B. And Mitchell, P. (2003) "What Separates The Winners From The Losers In New Food Product Development?", *Trends In Food Science & Technology,* 14(1-2), 58-64.

73. Straub, D., Rai, A. And Klein, R. (2004) "Measuring Firm Performance At The Network Level: A Nomology Of The Business Impact Of Digital Supply Networks", *Journal Of Management Information Systems,* 21(1), 83-114.

74. Stuart, I., Mccutcheon, D., Handfield, R., Mclachlin, R. And Samson, D. (2002) "Effective Case Research In Operations Management: A Process Perspective", *Journal Of Operations Management,* 20(5), 419-433.

75. Subramani, M. (2004) "How Do Suppliers Benefit From Information Technology Use In Supply Chain Relationships?", *Mis Quarterly,* 28(1), 45-73.

76. Subramaniam, M. And Youndt, M. A. (2005) "The Influence Of Intellectual Capital On The Types Of Innovative Capabilities", *Academy Of Management Journal,* 48(3), 450-463.

77. Subramanian, A. And Nilakanta, S. (1996) "Organizational Innovativeness: Exploring The Relationship Between Organizational Determinants Of Innovation, Types Of Innovations, And Measures Of Organizational Performance", *Omega,* 24(6), 631-647.

78. Takeishi, A. (2001) "Bridging Inter-And Intra-Firm Boundaries: Management Of Supplier Involvement In Automobile Product Development", *Strategic Management Journal,* 22(5), 403-433.

79. Talluri, S., Narasimhan, R. And Chung, W. (2010) "Manufacturer Cooperation In Supplier Development Under Risk", *European Journal Of Operational Research,* 207(1), 165-173.

80. Thorelli, H. B. (1986) "Networks: Between Markets And Hierarchies", *Strategic Management Journal,* 7(1), 37-51.

81. Van-Hoek, R. I., Harrison, A. And Christopher, M. (2001) "Measuring Agile Capabilities In The Supply Chain", *International Journal Of Operations & Production Management,* 21(1/2), 126-148.

82. Van-Maanen, J. E. And Schein, E. H. (1977) *Toward A Theory Of Organizational Socialization*, MIT Alfred P. Sloan School Of Management, Unpublished.

83. Verona, G. (1999) "A Resource-Based View Of Product Development", *Academy Of Management Review,* 24(1), 132-142.

84. Voss, C., Tsikriktsis, N. And Frohlich, M. (2002) "Case Research In Operations Management", *International Journal Of Operations & Production Management,* 22(2), 195.

85. Wathne, K. H. And Heide, J. B. (2004) "Relationship Governance In A Supply Chain Network", *Journal Of Marketing,* 68(1), 73-89.

86. Watts, C. A. And Hahn, C. K. (2006) "Supplier Development Programs: An Empirical Analysis", *Journal Of Supply Chain Management,* 29, 10-17.

87. Wernerfelt, B. (1984) "A Resource-Based View Of The Firm", *Strategic Management Journal,* 5, 171-180.

88. Williamson, O. E. (1991) "Comparative Economic Organization: The Analysis Of Discrete Structural Alternatives", *Administrative Science Quarterly,* 36(2), 269-296.

89. Wolfe, R. A. (1994) "Organizational Innovation: Review, Critique And Suggested Research", *Journal Of Management Studies,* 31(3), 405-431.

90. Wynstra, F., Van Weele, A. And Weggemann, M. (2001) "Managing Supplier Involvement In Product Development:: Three Critical Issues", *European Management Journal,* 19(2), 157-167.

91. Yin, R. K. (1989) *Case Study Research: Design And Methods,* Sage Publications.

92. Yin, R. K. (1994) *Case Study Research: Design And Methods, Applied Social Research Methods Series,* Sage Publications.

93. Yin, R. K. (2009) *Case Study Research: Design And Methods, Applied Social Research Methods Series,* Sage Publications.

94. Zaheer, A. And Bell, G. G. (2005) "Benefiting From Network Position: Firm Capabilities, Structural Holes, And Performance", *Strategic Management Journal,* 26(9), 809-825.

APPLYING GAMIFICATION TECHNIQUES TO STEM KNOWLEDGE ACQUISITION

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ABSTRACT

A fast evolving, technology-driven modern society increasingly needs well-trained science, technology, engineering and mathematics (STEM) college graduates equipped with innovative problem solving and higher order thinking skills. It is believed that they can be trained by teaching them the adequate level of scientific knowledge such as facts, concepts, rules and procedures at their different learning stages. Researchers have developed classification schemes to define different types of knowledge and those schemes can help adequately implement the design of instructional educations with the proper scientific knowledge to be taught. Usually, declarative or factual knowledge, which can be learned through memorization, is believed to be taught first because without the factual knowledge higher levels of knowledge, like advance problem solving, cannot be acquired. Once facts are clearly learned, then concepts, which are groups of related ideas that have common attributes, can be understood easily. Then other kinds of knowledge such as rules, procedures, strategies, and so on can be obtained. Then the combination of all those types of knowledge can help person solve problems innovatively.

Gamification refers to using game-like elements in non-game contexts to promote learning and engagement and help person engage in problem solving. It has been reported that these gamification techniques can help successfully deliver the different levels of knowledge. However, the gamification needs to be designed carefully to achieve the purpose. For example, people who lack the factual knowledge or an understanding of the basic concepts needed to perform certain procedures cannot be immersed into an educational game that focuses on teaching only the procedures. Therefore, the gamification techniques should be designed and developed to the right content at the right level.

The goal of our proposed research is to design and develop game-based mobile educational apps that can help educators teach STEM curriculum requiring a lot of the factual knowledge such as facts, jargon, and terminology and the conceptual knowledge by providing the appropriate content at the different levels of learning in collaboration with STEM educators.

We believe these game-based mobile educational apps can help people successfully obtain the required knowledge and become well-trained STEM workforce with innovative problem solving skills in the future.

REFERENCE

1. Kapp, K.M. (2012) The Gamification of Learning and Instruction: Game-based Methods and Strategies for Training and Education. Pfeiffer: San Francisco, CA.

2. Alavi, M. and Leidner, D. (2001) Review: Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues, MIS Quarterly , Vol. 25, No. 1 (Mar., 2001) , pp. 107-136

3. Deterding, S. , Dixon, D., Khaled, R. and Nacke, L. (2011). From game design elements to gamefulness: Defining "gamification", Proceedings of the 15th International Academic MindTrek Conference. pp. 9–15.

ENTREPRENEURSHIP DRIVERS AND BARRIERS IN NORTHERN SPARSELY POPULATED AREAS

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ABSTRACT

Purpose: Entrepreneurs in northern sparsely populated areas face context-specific challenges, as they develop their businesses; this is due to limited resources, remoteness, and long distances. The purpose of this study is to describe and classify the main drivers and barriers these entrepreneurs have experienced before the establishment of the company and at the start-up stage.

Design/methodology/approach: This is a sequential incident case study, focusing on sparsely populated areas in Northern Finland. The empirical data were gathered through semi-structured interviews with 25 entrepreneurs. The interviews were conducted face-to-face during the autumn of 2013. Multiple perspectives were analysed and evaluated, using an inclusive process, and the main findings were summarised.

Findings: As a result, both internal and external drivers and barriers faced by the entrepreneurs prior to establishment of the company and at the start-up stage were described and classified (specifically, internal drivers and barriers are person-based, and external drivers and barriers are environment-based). This case study also seeks to find drivers and barriers from the entrepreneur's perspective, in the context of northern sparsely populated areas.

Research limitations/implications: This study is limited to interviewed case companies located in Northern Finland, to get an in-depth understanding of the phenomenon.

Practical implications: Public business services can benefit from the results of this study when developing and tailoring their services. Also, the findings can be utilised by educational organisations located in northern sparsely populated areas, when encouraging students towards entrepreneurship.

Originality/value: *The current literature provides only limited information about the drivers and barriers experienced by entrepreneurs in northern sparsely populated areas. The scope of this study is focussed on the stages prior to establishment and start-up.*

Keywords: drivers and barriers, entrepreneurship, sparsely populated areas, start-up stage, growth

Category: Case study

INTRODUCTION

Entrepreneurs in northern sparsely populated areas (NSPA) face context-specific challenges as they develop their businesses; these include limited resources, remoteness, and long distances. The purpose of this study is to describe and classify the main drivers and barriers to entrepreneurship that entrepreneurs in NSPA have experienced, before the establishment of their company and at the start-up stage.

The current literature provides limited information about drivers and the barriers to entrepreneurship experienced by entrepreneurs in NSPA. The scope of this study is focussed on the stages prior to establishment and start-up.

This is a sequential incident case study, focusing on sparsely populated areas in Northern Finland. The empirical data were gathered through semi-structured interviews of 25 entrepreneurs. The interviews were conducted face-to-face with these entrepreneurs in the autumn of 2013.

The research question is "What drivers and/or barriers to entrepreneurship did the entrepreneurs face, prior to the establishment and at start-up stage in NSPA?"

After the interviews, the internal and external drivers and barriers faced by the entrepreneurs prior to establishment and at start-up stage in NSPA, were described and classified (note here that internal drivers and barriers are person-based, and external drivers and barriers are environment-based). In addition, this case study seeks to determine drivers and barriers from an entrepreneur's perspective, in the context of northern sparsely populated areas.

The present study is made up of five sections. In the introduction section, the background, motivation, research problem, and research questions are presented. In the second section, the theoretical background of the study is presented. In the third section, the method undertaken in this study is described. In the fourth section, the description and analysis of the data garnered from the interviews are undertaken; these findings are then examined in light of the research questions. In the final section, a discussion of the main results and opportunities for further research are presented.

THEORETICAL FRAMEWORK

Drivers and barriers to entrepreneurship

A person's decision to establish a company is affected by many factors: for example, the existence of opportunity, entry barriers, skills, and preferences (Commission of the European Communities, 2003). Huuskonen (1992) has divided the factors affecting the establishment of a company into three main categories: a) personality factors, b) background factors, and c) situational factors. In general, drivers and barriers are divided into categories of internal and external (bearing in mind that internal drivers and barriers are person-based, and external drivers and barriers are environment-based). Examples include: prior entrepreneurship experience as an internal driver, the possibility of buying a business as an external driver, fear of failure as an internal barrier, and an unsupportive business environment as an external barrier. Internal barriers exist inside the person themselves, but external barriers are independent of the person (Raeesi *et al.* 2013).

Entrepreneurship drivers are factors that cause a person to choose entrepreneurship instead of other career possibilities, and causes them to work to achieve entrepreneurship (Hessels *et al.* 2008; Naffziger *et al.* 1994). Traditionally the motivations to establish a company have been divided into either push or pull factors. For example, a lack of alternative employment opportunities may push the person to entrepreneurship, but identified business opportunities may pull the person to entrepreneurship (Rissanen *et al.* 2011; Szarucki, 2009).

Entrepreneurship barriers are factors that prevent or hinder a person from establishing a company. Barriers to entrepreneurship are numerous; they can vary, depending on the individual or group, can have different strengths, and have effects in different combinations (Finnerty and Krzystofik, 1985; Kouriloff, 2000). According to Raeesi *et al.* (2013), internal barriers are very often brought about by external barriers. For example, the variety of entrepreneurship barriers may depend on the industry sector, the region, or the type of company (Martins *et al.* 2004). These entrepreneurship barriers may be related to psychological, economic, political, or cultural factors (Kouriloff, 2000) and can be divided into the categories of autonomous, dependent, linkage, and independent (Raeesi *et al.* 2013). Understanding of barriers may vary from person to person, depending on time or the situation. Common entrepreneurship barriers can be categorized as: a) regulatory barriers, b) cultural and social barriers, and c) financial and economic barriers (Commission of the European Communities, 2003). Entrepreneurship barriers can also be divided into entry barriers and survival barriers (Raeesi *et al.* 2013). To the individual, a barrier can be actual or perceived (Finnerty and Krzystofik, 1985).

The most significant barriers to rural entrepreneurship can be divided into three main categories: obstacles related to a) the small size and low density of rural communities, b) the social and economic structure of rural communities, and c) the nature of internal and external linkages (Martins *et al.* 2004).

The stages of sequential frame for classification of the drivers and barriers

As stated above, the purpose of this study is to describe and classify the main drivers and barriers to entrepreneurship, those that entrepreneurs in NSPA have experienced, prior to the establishment of their company, and during the start-up stage. A growing company has to deal with both stages and transitions. The term 'stage' corresponds to the configuration of variables that a growing company is likely to face, and the term 'transition' means the reconfiguration of these variables (Hanks and Chandler, 1992; Galbraith, 1982). Literature focussing on stages of business development represents a process perspective on growth. The focus of the literature (i.e. stages of growth, lifecycle, or configuration) is on what happens during the early stages of development (e.g. Churchill and Lewis, 1983; Greiner, 1972; Kazanjian, 1988) and how early development can be managed (see Davidsson and Wiklund, 2006; Wiklund, 1998).

Figure 1. The developmental stages as the focal point of analysis of drivers and barriers to entrepreneurship

The framework for analysis of the early stages of growth was identified earlier, based on a literature review (Muhos, 2011). Based on analysis of fourteen recent and relatively consistent models, the early stages of technology-intensive stages (SMEs) were defined as conception and development, commercialisation, expansion, and stability/renewal. While technology-business-focused frameworks present a) the conception and development stage and b) the commercialisation stage as two separate stages, in the frameworks focusing on service businesses, both these stages have been labelled as the start-up stage. The study is focused on the time prior to the establishment and start-up stages; these stages are illustrated in figure 1.

Northern sparsely populated areas (NSPA)

The NSPA are faced by the impact of major global trends, such as climate change and its impacts on people, demographic change, and rapid economic and environmental changes, due

to large-scale industrial projects. Entrepreneurship in these areas faces operational challenges, such as obtaining financing by start-up companies, and the long distances from support facilities. This is similar to the problems faced by companies on the periphery also: a small customer base, long distances to market, and a generally poor business environment. Also, micro-sized companies commonly lack experience or traditions of cooperation with enterprises outside the local area (Clement, 2014).

Challenges in the availability of finance are highlighted in northern sparsely populated areas. Remoteness brings extra costs and challenges for communications, logistics, and transportation, as well as increases in manufacturing costs and longer workforce commutes. Low population density may also limit the available skilled labour, as well as employment options generally.

METHOD

The present research took the form of a retrospective, multiple case study. 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'. In this study, the sequential incident technique (SIT) (Edvardsson and Roos, 2001; Fisher and Oulton, 1999) was used as a data collection technique. SIT is a specific type of critical incident technique (CIT) (Flanagan, 1954). Chell (2004, pp. 48-49) divides the main aspects of data collection to five phases: (1) introduction of the CIT method and getting the interview under way, (2) focusing the theme and giving an account of oneself as researcher to the respondent, (3) controlling the interview, by probing the incidents and clarifying one's understanding, (4) concluding the interview, and (5) taking care of ethical issues. The present study analysed the drivers and barriers faced by the entrepreneurs prior to establishment and at start-up stage of the business in NSPA. In this study, the empirical data were gathered through 25 semi-structured, face-to-face interviews. The research process of this study is presented in figure 2.

Figure 2. The research process (modified from Yin 1989)

Each interview was recorded and transcribed, and was then saved in a database. Each case study evidence was collected by a researcher trained in data-collection procedures, and who was familiar with the study's theoretical background. The data-collection process took place in autumn 2013; following this, an inclusive and iterative process was used to analyse the data, and the main findings were summarised. This study was limited to interviewed case companies located in Northern Finland to get in-depth understanding of the phenomenon.

RESULTS

In this section, we will describe the drivers and barriers to entrepreneurship faced by the 25 entrepreneurs prior to establishment and at start-up stage of the company in NSPA. Basic information about the 25 companies is presented in table 1.

The drivers are presented in table 2 and barriers in table 3. In both tables 2 and 3, the internal and /or external dimensions are presented with *INT* or *EXT* after each driver/barrier (the abbreviation *INT* stands for internal driver/barrier, and *EXT* external driver/barrier).

Table 1. Basic information about the companies

Company	Establishment year	Personnel in 2012 (full-time converted)	Turnover in 2012 euros	Status of business in 2013 (not operating, decreasing, stable, growth)
1	2003	1	10 000	stable
2	1994	1	10 000	decreasing
3	2009	1	3 000	stable
4	1997	1	8 000	not operating
5	1998	2	200 000	growth
6	2006	17	2 700 000	growth
7	1991	6	750 000	stable
8	2007	0	0	not operating
9	2009	1	3 000	stable
10	2003	17	1 400 000	growth
11	1994	1	9000	decreasing
12	2000	1	60 000	stable
13	1997	7	932 000	stable
14	2004	6	700 000	decreasing
15	2003	13	1 700 000	growth
16	1999	0,5	20 000	stable
17	2008	1	85 000	stable
18	2008	1	75 000	stable
19	2008	0	0	not operating
20	2008	1	55 000	stable
21	2008	4	150 000	growth
22	2009	5	230 000	decreasing
23	2005	6	300 000	stable
24	2006	4	540 000	not operating
25	2008	3	500 000	stable

The establishment year of the companies extended from 1991 to 2009. The average number of personnel in the companies was four, and average turnover nearly 350.000 euros. At the time of the interviews, five companies were on a growth path, twelve companies were in stable situation, six were in a decreasing phase, and four had stopped business. The main reasons for stopping business was either the health status of the entrepreneur or unprofitability of the business.

Table 2. Entrepreneurship drivers experienced by entrepreneurs prior to establishment and at the start-up stage in NSPA (INT = internal driver, EXT = external driver)

Prior to the establishment	Start-up stage
Participation in entrepreneurship / innovation courses [INT]	Possibility to start business along with paid work [EXT]
Experience of cooperative society / association activities [INT]	Earlier entrepreneurship experience [INT]
Experience of projects [INT]	Paid work offered economical security [EXT]
Education in the field [INT]	Possibility to develop the work [INT]
Hobby / long-term interest in the field [INT]	Possibility to start business on a small scale [INT]
Entrepreneurship in family / relatives [EXT]	Possibility to have premises at home [INT]
Working experience in the field / tasks [INT]	Support from family, friends, customers, other entrepreneurs
Need for extra income [INT]	Forbearing personality of the entrepreneur [INT]
No family to take care of [INT]	Pleasant contents of business activities [INT]
Old business / customer contacts [EXT]	No worries about gossip –personality [INT]
Dream to become an entrepreneur [INT]	Good competitive situation [EXT]
Earlier entrepreneurship experience [INT]	Public subsidies to develop business and employ [EXT]
Entrepreneurial attitude [INT]	Support from public business services [EXT]
Freedom to do things my way [INT]	Good business plan [EXT]
Stressful paid work [EXT]	Discussions with people in the same field [EXT]
Personal ambition [INT]	Versatility of business activities [EXT]
Hope of financial success [INT]	Success in business [EXT]
No paid work available in the field [EXT]	Success in recruitment / investments [EXT]
Support from family, friends, customers, other entrepreneurs	Good business premises [EXT]
Seasonality of the paid work [EXT]	Regulations [EXT]
Divorce [EXT]	Commitment / support from the stakeholders [EXT]
Spouse´s economic education [EXT]	Bank trusted entrepreneur in difficult situation and gave loan
Father´s health status [EXT]	Positive public discussion in town [EXT]
Success in paid work [EXT]	
Noticing the need / idea in paid work [EXT]	
Good competitive situation [EXT]	
Ideas from other entrepreneur [EXT]	
Cooperation possibilities with familiar company/association	
Possibility to use own land, buildings etc. [EXT]	
Partner organisation´s positive attitude [EXT]	
Subcontracting possibility offered by a bigger company [EXT]	
End of the market monopoly [EXT]	
Possibility to have public subsidies to start business [EXT]	
Finding a good partner [EXT]	
Business possibility due to bankruptcy of another company [EXT]	
Familiar town and people [EXT]	
Location of good premises [EXT]	
Opportunity to buy a company [EXT]	
Strong desire to own business [INT]	
Lay-off from paid work [EXT]	

Interviewed entrepreneurs mentioned in total 63 entrepreneurship drivers; 22 of these were internal and 41 were external. They attributed 40 drivers to the stage before establishment, and 23 drivers to the start-up stage.

Many drivers, listed in the table 2, were mentioned several times by the interviewed entrepreneurs. The most common driver prior to the establishment stage, was participation in entrepreneurship/innovation course. The large part of the drivers prior to the establishment stage is related directly to the entrepreneur (e.g. working experience and/or education in the field; entrepreneurship experience; entrepreneurship dream; entrepreneurial attitude) and his/hers relatives (entrepreneurship in family/relatives, support from family). A single incident (e.g. opportunity to buy a company) was also mentioned several times as a driver prior to the establishment stage.

At start-up stage, the most common driver was the support from family, friends, customers and other entrepreneurs. Major part of the drivers at the start-up stage are related to financial aspects (e.g. public subsidies to start business, develop and employ; bank trusted

entrepreneur), premises, and the support from public business services. Also the possibility to start business along with paid work was mentioned several times as a driver at start-up stage.

Table 3. Entrepreneurship barriers experienced by entrepreneurs prior to establishment and at the start-up stage in NSPA (INT = internal barrier, EXT = external barrier)

Prior to the establishment	*Start-up stage*
Economical risks [INT]	Weak credibility of a new firm [EXT]
Risk of too much work [INT]	Need to have paid work alongside the business [EXT]
Insecure livelihood of the family [INT]	Lack of marketing / pricing know-how [INT]
No public safety net for entrepreneurs [EXT]	Negative attitude of municipal public servants [EXT]
Negative attitude of public business services [EXT]	Lack of capital / difficulties of access to finance [EXT]
Company name regulations [EXT]	Long payment times for bills [EXT]
Difficulties in stopping business in Finland [EXT]	Time window for the idea not yet open [EXT]
	General envy and/or negative atmosphere [EXT]
	Tough competitive situation in the market [EXT]
	Small company has very limited financial leeway [EXT]
	Strained financing possibilities [EXT]
	New competitors [EXT]
	Tax regulations [EXT]
	Didn't find right contacts [EXT]
	Employer obligations [EXT]
	Too much work [EXT]
	Slow growth of the business [EXT]
	Lack of collateral [EXT]
	Authority did not grant public subsidy to start business [EXT]
	Neighbour made a public complaint [EXT]
	Errors made by authorities (incorrect license demands) [EXT]
	Home location doesn´t work [EXT]
	Many small payments are charged from young companies [EXT]
	Difficult to get signposts [EXT]
	Authority changed the form of public subsidy [EXT]
	No workable public subsidy available for R&D phase of new company with no sales record yet [EXT]
	Weak business period among customer companies [EXT]
	Inflexible terms of public loans [EXT]
	Principles of public tending to favor bigger companies [EXT]
	The lack of cooperation between public administrative sectors [EXT]
	Social sector´s regulations [EXT]
	Differences in legal requirements in different towns [EXT]
	Dishonest people can start new businesses again and again [EXT]
	Distribution of marketing information doesn´t work in public organisations [EXT]
	Population base is too small [EXT]
	Social pressure in sparsely populated areas to continue an unprofitable part of a business (so-called charity aspect) [EXT]
	Small family company can´t get public energy subsidies [EXT]

Interviewed entrepreneurs mentioned in total 44 barriers, of which four were internal and 40 external. Regarding barriers, only seven were attributed to the stage before establishment, and 37 to the start-up stage.

Many barriers, listed in the table 3, were mentioned several times by the interviewed entrepreneurs. The most common barrier prior to the establishment stage, was economical risk. Another common barrier was the unsecure position of the entrepreneur in the society (no

public safety net for entrepreneurs). One interesting barrier prior to the establishment stage, arose in this study, is the difficulties in stopping business, which was also pointed out by Martins *et al.* (2004).

At start-up stage, the major part of the barriers is related to financial aspects (e.g. lack of capital and collateral, difficulties of access to finance) and regulative aspects (e.g. tax regulations, employer obligations, errors made by authorities). Surprisingly a common barrier at start-up stage was the skeptic attitude of the public business services and municipal public servants.

DISCUSSION

This study described the main drivers and barriers to entrepreneurship experienced by 25 entrepreneurs before the establishment and at start-up stage of the company in NSPA. Drivers and barriers were classified into internal and external categories in order to minimise the loss of information. The entrepreneurs were not given ready-made alternatives during the interviews in order to find out wider range of drivers and barriers. Most of the experienced drivers and barriers were environment-based (external). Entrepreneurs experienced more drivers prior to the establishment stage than at the start-up stage. In contrast, they experienced more barriers at the start-up stage than prior to the establishment stage.

Entrepreneurs in northern sparsely populated areas face context-specific challenges as they develop their business due to limited resources, remoteness and long distances. The interviewed entrepreneurs emphasized the importance of family and relatives as a driver to entrepreneurship. Family centered culture can be seen as a significant enabler for new business. The local experience and traditions of cooperation with enterprises appears to be meaningful for the entrepreneurs in NSPA. Based on the interviews, financial challenges were mentioned as typical barriers. Small population base and low density increase business risks. Even a small change in competitive situations can be crucial to the business.

The fact, that the possibility to start business along with paid work, was mentioned several times as a driver at start-up stage. This clearly points out the need for public actors to check, if the public business service system adequately takes into account the needs of part-time entrepreneurs.

Surprisingly a common barrier at start-up stage is the skeptic attitude of the public business services and municipal public servants to the business ideas and development needs of the start-up companies. This can be partly explained by the structure of the public business service system, which is essentially built on the basis of the needs of larger companies.

When evaluating the results, it should be taken into account that in some cases a long time had passed since the establishment of the company; this may have weakened some interviewees' recall of details. Considering the sequential character of the process, the use of SIT proved effective for open-ended analysis of both of drivers and barriers for entrepreneurship. The construct validity of the study was based on a sound research plan,

multiple sources of evidence, qualitative data, and an established chain of evidence. Analytic generalisation (i.e. generalisation to a theory) of the findings was possible for building context-specific models and theories. However, the findings of the present study cannot be generalised to other countries or business contexts, and are based on the time of data collection. Case-study protocol was followed and a database was established, permitting further testing of the findings. In future studies, other types of regions could be evaluated, by taking advantage of the research strategy presented in this study. Moreover, the context of NSPA should be studied further using more cases and in-depth analyses of different industries and sectors.

ACKNOWLEDGEMENTS

REFERENCES

1. Chell, E. (2004), "Critical incident technique", In: Cassell C & Symon G (eds) *Essential Quide to Qualitative Methods in Organisational Research*. London, SAGE Publications, pp. 45-60.
2. Churchill, N.C. and Lewis, V.L. (1983), "The five stages of small business growth", *Harvard Business Review*, 61 (3), pp. 30–50.
3. Clement, K. (2014), *Strategic Environmental Assessment of the Northern Periphery and Arctic Programme 2014-2020*, European Policies Research Centre , University of Strathclyde ,Glasgow United Kingdom
4. Commission of the European Communities (2003), "*Green Paper, Entrepreneurship in Europe*". COM(2003), 27 final, 21.1.2003, Brussels.
5. Davidsson, P. and Wiklund, J. (2006), "3. Conceptual and empirical challenges in the study of firm growth", in *Entrepreneurship and the Growth of Firms*, Cheltenham: Edward Elgar Publishing.
6. Edvardsson, B. and Roos, I. (2001), "Critical incident techniques", *International Journal of Service Industry Management*, 12(3), pp. 251–268.
7. Finnerty, J. F., Krzystofik, A. T. (1985), "Barriers to small business formation", *Journal of Small Business Management*, 23 (3), pp. 50–58.
8. Fisher, S. and Oulton, T. (1999), "The critical incident technique in library and information management research", *Education for Information*, 17(2), pp. 113–125.
9. Flanagan, J.C. (1954), "The critical incident technique", *Psychological Bulletin*, 51 (4), pp. 327–358.

10. Galbraith, J. (1982), "The stages of growth", *Journal of Business Strategy*, Vol. 3, No. 1, pp. 70–79.

11. Greiner, L. (1972), "Evolution and revolution as organizations grow", *Harvard Business Review*, 50 (4), pp. 37–46.

12. Hanks, S.H., Chandler, G.N. (1992), "The growth of emerging firms: a theoretical framework and research agenda". *The proceedings of 7th Annual National Conference of the United States Association for Small Business and Entrepreneurship*. Chicago, United States Association for Small Business and Entrepreneurship.

13. Hessels, J., van Gelderen, M., Thurik, R. (2008), "Entrepreneurial aspirations, motivations, and their drivers", *Small Business Economics*, 31 (3), pp. 323–339.

14. Huuskonen, V. (1992), *The process of becoming an entrepreneur* (In Finnish: *Yrittäjäksi ryhtyminen: Teoreettinen viitekehys ja sen koettelu*), Turun Kauppakorkeakoulun julkaisuja, Sarja A-2, Raision Painopojat, Raisio.

15. Kazanjian, R. (1988), "Relation of Dominant Problems to Stages of Growth in Technology-Based New Ventures", *The Academy of Management Journal*, Vol. 31, No. 2, pp. 257-279.

16. Kouriloff, M. (2000), "Exploring perceptions of a priori barriers to entrepreneurship: A multidisciplinary approach", *Entrepreneurship Theory and Practice*, 25 (2), pp. 59–79.

17. Martins, S., Couchi, C., Parat, L., Federico, C., Doneddu, R., Salmon, M. (2004), "Barriers to entrepreneurship and business creation", available at: http://www.adrimag.com.pt/ (accessed 13 March 2014).

18. Muhos, M. (2011), *Early stages of technology intensive companies*, University of Oulu, Oulu.

19. Naffziger, D. W., Hornsby, J. S., Kuratko, D. F. (1994), "A proposed research model of entrepreneurial motivation", *Entrepreneurship Theory and Practice*, 18 (3), pp. 29–42.

20. Raeesi, R., Dastranj, M., Mohammadi, S., Rasouli, E. (2013), "Understanding the interactions among the barriers to entrepreneurship using interpretive structural modeling", *International Journal of Business and Management*, Vol. 8, No. 13, pp. 56-72.

21. Rissanen, S., Hujala, A., Laukkanen, V., Helisten, M., Taskinen, H. (2011), "Start-up motivations and growth orientation of owners of family business - a care entrepreneurship approach", *Electronic Journal of Family Business Studies*, Issues 1-2, Vol. 5, pp. 55–73.

22. Szarucki, M. (2009), "Entrepreneurial start-up motives in transitional economy – case of Poland", *Business Excellence*, Vol. 3 No. 2, pp. 9-21.

23. Wiklund, J. (1998), *Small Firm Growth and Performance: Entrepreneurship and Beyond*, Jönköping, Jönköping University: Jönköping International Business School.

24. Yin, R. (1989), *Case Study Research: Design and Methods*, Sage Publishers, Beverly Hills.

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TAKING REFUGE COGNITIONS AND BEHAVIORS OF THE LATENT DISABLES IN THE UNDERGROUND SPACE

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ABSTRACT

The building type of Taiwan for satisfying people needs trend toward high, huge, compound and underground space. When the fire happened, the disables could hinder people from fleeing and taking refuge. How to help the disables take refuge is that the government should think and plan about. Based on the dangerous situation in the underground space, to stipulate appropriate strategy of taking refuge, to set administration modus operandi, and to publicize correct concept of fleeing and taking refuge, those would supplement insufficient situations of putting out the fire.

This research, by questionnaire investigation and statistical analysis, study the relative disables in underground space whose the connection between the cognition of disaster prevention and behaviors of fleeing and taking refuge. The result shows that "the latent physical and psychological situation" and "the latent taking refuge situation" could explain "the latent taking refuge situation in the underground space". Also "the latent taking refuge situation" is an important intermediary role. The relative disables indeed exist in general people by the structural equation model (SEM) analysis. When carrying on comparative analysis with man and women, men are "the relative disables"; when carrying on comparative analysis with age, 21~30 year old and 51~60 year old, those are "the relative disables".

Keywords: building, underground space, administrative modus operandi, structural equation

model (SEM), latent, fleeing and taking refuge

INTRODUCTION

People must contest against the spread speed of flam and heavy smoke falling speed, when the fire is happened in the Large-scale underground space. When the outage and fire alarm worked, people in the dark underground space hope to reach the emergency exit during the shortest time. No matter on horizontal or vertical route at this moment, fire fighter and general people, could be colliding, pushing, shoving and conflict, etc[1] ; it would postpone being rescued. The longer of time the people stay on the underground space is, the more the casualties is increasing.

At this moment, people whose health is not well, feeling strange about the underground space, having no disaster prevention cognitions, would hinder the fire fighter from entering to put out the fire and to rescue people, would also influence speed of taking refuge and fleeing of general people. In case, people falling or tripped, which become the obstacle of fleeing or moving to take refuge, even stop up the emergency exit. Predictable people will die around the emergency exit [2]. Under the taking refuge and fleeing situations, the elders also belong to not good health.

According to the statistical data of Directorate-General of Budget, Accounting and Statistics, Executive Yuan, Taiwan R.O.C. [3] ，till the end of March of 2011, numbers of people have already been close to 2,550,000 people and account for 10.7% of national total numbers of people over 65 year-old in Taiwan. The government estimated until 2030, the number of the elder will surpass the already developed countries or areas [4] in the world. It has already marched toward to the old-age society. Additionally, 41,185 people in Taiwan live in the long-term care center at the end of 2008; 181,000 people are cared for foreign maid [4]. According to the statistical data from National Fire Agency, Ministry of the Interior [5], from 1997 to 2009, the building fire is the most number of times in all kinds of fire. Taking 2009 as an example, the building fire was happened 2621 times.

When the fire accident happened, people take refuge voluntarily or passively according to self disaster prevention cognition, fire-proof education daily. Therefore, the fleeing moving speed is the most important reason for success of fleeing and taking refuge. In other words, people contest against time [6].

How to inhibit the heavy smoke falling speed; how to get more time for people taking refuge and fleeing; how to leave the fire place unhurriedly before the heavy smoke falling down; how to avoid people injured by high temperature; those narrated above should be protected by apparatus and facility. And meanwhile, to access or judge the software and hardware apparatus and facility, the performance or specification has been enough. However, when the fire happened, if people lack the correct thoughts and behaviors of fleeing and taking refuge, even if the government organ, the relevant unit plan to set up and improve facilities and apparatus, will also make a futile effort.

RETROSPECT OF LITERATURE

Definition of Large-Scale Underground Space

According to scholar's research [7], the Underground Street (or underground space) can distinguish two kinds of standards: one is the area of floor; the other is the shop quantity. When the area of floor in Underground Street is larger than 10,000 m^2 or the shop quantity is more than 100 units, it belongs to the large-scale underground street. The definition of the scale underground street is shown in Table 1. The definition of large-scale or specific buildings [8] is shown in Table 2.

Table 1 definition of the scale of Underground Street

Type	Area (m^2)	Number of Store	Examples
Small-Size	<3,000	<50	Japan，Fukuoka，Kyoto Station
Middle-Size	3,000~10,000	30~100	Japan，Tokyo，Shibuya underground street
Large-Size	>10,000	>100	Japan，Tokyo，Yaesu underground street

Table 2 the condition of large-scale or specific buildings

Condition	Definition
large-scale building	■ The height of n floor exceeds the building of 60m ■ The area of floor of total floor exceeds the single building of 25,000 m^2 or constructs the building together
specific building	■ Underground street or underground store where n links with underground public transportation system

Definition of the Weaker of Taking Refuge

Usually, the weaker of taking refuge refers to the elder, the patient (including the physical and psychological obstacle person), child and pregnant woman, one who needs to be assisted by others. The Disaster Prevention White Paper [9] edited by Ministry of Land, Infrastructure, Transport and Tourism in Japan, in Yu Ping 3-year, pointed out the definition of the weaker of taking refuge including:

(1) Person can't perceive dangerous situation or being difficult to perceive dangerous information. Even person perceiving dangerous situation is unable to take appropriate action, or being difficult to take action.

(2) Person has the ability to perceive dangerous information, but being unable or difficult to get it. Even person has ability to get dangerous information, but being unable or difficult to take appropriate action.

(3) "Behavior of taking refuge" means that person meeting dangerous situation can take "appropriate action". Unfortunately, "the weaker" defined above is 69% of the number of casualties of fire learned from the physiological state materials [10] of person died in fire disaster in Japan.

Fire Characteristic in the Underground Space

From the statistical data, fire and floods [11] are often happened in underground space which is gathering people, as railway, mass rapid transportation and underground street etc. The underground space is airtight; when the calamity accident happened, in the dark and closed limitation space, made difficulty for person of taking refuge and rescuing, increased injury [12] of the calamity. The fire characteristic in the underground space is as follows:

(1) The opens to outside or the pass way in the underground space is limited in quantity and airtight. It's difficult for fire fighters to control the situation within the underground space. Also people in the underground space are not easy to figure out the situation on the ground. It's difficult to find the ignition position. It's not easy to control the fire state, the limitation of exits and entrances cannot hold a large number of rescued person and equipments at the same time [11].

(2) The underground space is a kind of "room without windows or floor without opens". The air supplied is limited. After the fire happened, the state is smoked because of burning not totally (lack O_2). The fire state will be more serious, when the fire caused by cable, electricity. Moreover the underground space connect with other facilities construct together, no matter where the fire take place, it will spread to another direction. The structure of the underground space is complicated; the fire spreads fast and becomes unstable state, increasing danger [11] of people and fire fighters.

(3) The automatic fire extinguishing system or fire fighter irritates the water accumulation situation incident while rescuing, hinder rescuing and flee for one's life and cause the serious water to decrease [11].Fleeing is limited by the quantity, width, position of exits to the ground. If the structure, space, direction and route are closed and unrecognized, it is easy to get lost. It is easy to feel tired to reach the ground by walking stairs vertically [12].

(4) The nature light and air are not easy to supply because of the opens less. It is easy to accumulate the harmful gas and high temperature. Once high temperature combustible gas contact the fresh air, it easy to produce exploding, back-firing or fire-flashing [12].

(5) It will delay the opportunity of rescuing when the route of rescuing is opposite to the route of taking refuge. The communication contact from underground to ground is difficult because of the distance. The fire fighters need to depend on air respirator, entering to rescue. The fire fighter can't enter the fire place at the same time; because the capacity of air respirator is limited, the quantity, width, distance, route and space of exits is limited, the equipments supplied and rescuing area are limited [12] too.

(6) The heat, smoke and gas of fire will accumulate and flow in the route of taking refuge. It is often same direction as the route of taking refuge that the fire smoke spreads and flows. The light or illumination is insufficient, the heavy smoke covers the sight badly, and it will influence the choice of the route of people fleeing. Under high temperature, heavy smoke situation, people produce the negative psychology such as being uneasy, panic, dangerous behaviors [12] of following blindly, oppression, crowded etc.

METHOD

By relevant regulation, documents and materials [13, 14, 15, 16, 17], the fire happened in the underground space (such as underground transport station, subway or underground street), there is no rules or regulation about the weaker of taking refuge (not good health, feeling strange about the underground space or have no enough thoughts of disaster prevention) in the technological progress country of the world. According to the painful fire case reports in the past [18, 19, 20, 21], the fire happened in the underground space, people is frightened, out of control, confused, collide each other, etc.; therefore, casualties and property loss make anticipated more serious situation can be seen.

The fire case [18, 19, 20, 21] in the past, the fire was often happened in the underground space because of the contingency (such as electric wire short circuit), the commit arson (such

as explosion) or earthquake.

At first, this research collects the domestic and foreign relevant documents and materials, including space cognition, behaviors of taking refuge, stratagem of fleeing, rescuing, countermeasure of personnel evacuating and regulation of buildings and fire prevention. Collecting the relevant fire cases to sort out and analyze is the second step. At last, by expert interviewing, questionnaire investigation and structural equation analyzing is to understand the cognition and behavior of taking refuge of people in the underground space.

RESULTS OF STUDY

This research examines the relation during "potential physical and psychological state", "the potential state of taking refuge" and "potential underground space state" by the structural equation. From Fig. 2, "potential physical and psychological state" turns the standard route coefficient into 0.34 to "the potential state of taking refuge"; "potential physical and psychological state" turns the standard route coefficient into 0.13 to "the potential underground space state"; "the potential state of taking refuge" turns the standard route coefficient into 0.69 to "the potential underground space state". The indirect result of this way is 0.34*0.69 =0.23; the direct result is 0.13; the indirect result is greater than the direct result "the potential state of taking refuge" is "the intermediary role" between "potential physical and psychological state" and "the potential underground space state".

"Right indicator" can check whether a model passes every standard. By the structural equation analysis chart Normed chi-square =1.625 < 3, GFI =0.975 >0.9, AGFI =0.952 >0.9, CFI =0.986 >0.9, RMSEA =0.045<0.08; It can be proved the model is appropriate, the structure of the model is good, as shown in Fig. 2.

Basically this research builds the right indicator and supposition of structure equation is standard, then using the comparative analysis in many groups to explore every structure equations among groups, pursuing to perceive "the weaker of take refuge". The items of comparative analysis of groups comprise men and women as a group separately, and under the age of 20, 21- 30 years old, 31- 40 years old, 41- 50 years old, 51- 60 years old, over the age of 60 as one group of groups separately.

This research tries to set up theory model by social science research approach, to find out existence possibility of the "relative" weaker of taking refuge in underground space. According to the analysis result, find "the potential underground space state" can be

explained by "potential physical and psychological state" and "the potential state of taking refuge" at first, and meanwhile "the potential state of taking refuge" is "the intermediary role". Hence "the relative weaker of taking refuge" exactly exists among the masses of people. Analyzing with the group of man and woman, man group is the relative weaker of taking refuge; Analyzing with the group of age level, 21- 30 years old, 31- 40 years old and 51- 60 years old, the three kinds of age level groups are the relative weaker of taking refuge.

Fig. 2 the structure equation analysis chart

Note:

A	potential state of taking refuge	B	potential physical and psychological state	C	potential underground space state
A1	Cognition of disaster prevention	B1	Characteristic of personnel	C1	space closeness
A2	Behavior of disaster prevention	B2	health	C2	Information fuzziness
A3	characteristic of taking refuge	B3	exercises	C3	fleeing difficulty

Everyone should pay attention to one's own physical and psychological state, keep good health and exercise habits, learn the correct knowledge of taking refuge. When the fire

happened, people can recognize the characteristic of underground space (space closeness: no window, no nature light and no ventilation; Information fuzziness: sight fuzzy because of lightless, powerless and heavy smoke; fleeing difficulty: fleeing horizontally and vertically under high temperature and heavy smoke). Secondly, people should upgrade and strengthen the knowledge of taking refuge. This research find "the relative weaker of taking refuge" (younger generations of 21~30 years old, young group of 31~40 years old and prime generations of 51~60 years old, especially male) should be strengthened and reminded those behavior and knowledge of taking refuge even more.

According to the statistics analysis and a lot of cases reveal, the reason of people's injuries and deaths, lack the correct knowledge and action of fleeing and taking refuge. This research works out the questionnaire for general knowledge and relevant theory of disaster prevention, builds "potential physical and psychological state", "the potential state of taking refuge" and "the potential underground space state" three kinds of "potential changeable one". Utilizing structural equation and statistical method, the purpose is to find out "observable changeable one" from "potential changeable one", to utilize "intermediary result" verifying "observable changeable one", to understand people of different groups whether carry on the behavior of taking refuge in underground space according to "physical and psychological state". If the route coefficient from "potential physical and psychological state" to "the potential state of taking refuge" is "apparent", the people of this type think to be enough to deal with the state of urgent danger and disaster, in the underground space, according to one's own health state, moving state, body function and determination etc. The route coefficient from "potential physical and psychological state" to "the potential state of taking refuge" is "not apparent"; the people of this type think to have knowledge and method of disaster prevention helping fleeing from the scene of fire safely.

The weaker in this research is relative potential the weaker of taking refuge. It means the person who takes action to flee without correct thoughts and methods of taking refuge. When the fire happened, people can flee successfully because of the correct thoughts and methods of fleeing and taking refuge, but not of strength or health. The confidence level in this research is 95%. In other words, if estimate the parent with the effective sample of this research, there are 5% of the error values, so does not show all behaviors of taking refuge in this research. However, these researches still have its reference value as to government's relevant units.

CONCLUSIONS AND SUGGESTIONS

By structural equation model (SEM) in this research, it is to find out people cognition in psychological aspect. By "the potential state of taking refuge" intermediary role, it is necessary to strengthen and possess correct thoughts of disaster prevention. In other words, general people could be the weaker on the psychological aspect; the disables could not be the weaker on the psychological aspect by rising correct thoughts of disaster prevention and methods of taking refuge. When the situation of danger and disaster happens in the underground space, it can improve the successful probability of fleeing and taking refuge.

According to this research results, the state of taking refuge in underground space can be explained by "the physical and psychological state" and "cognition of disaster prevention". The physical and psychological state of male group is relatively good, do not possess correct knowledge and method of fleeing and taking refuge, may also die when the fire takes place. The physical and psychological state of self-awareness of female group is relatively weak, care about knowledge and method of fleeing and taking refuge, cooperate with relevant stipulate, improve probability of success of taking refuge. Base on the analysis result of this research, the weaker of taking refuge is not the disable people. The definition of "the weaker of taking refuge" can be expanded with this research results, have no correct thoughts of disaster prevention, be unable to think calmly and do not realize the knowledge of fleeing. The government and relevant unit can stipulate more overall tactics and contents of taking refuge, draft more complete policy of education and training. Make everyone possess thoughts and methods of taking refuge and fleeing.

ACKNOWLEDGMENTS

REFERENCES

1. Lin Ching-Yuan, Chuang Ying-Ji, Chang Shang-Wen, Wu Wu-Tie, "*Research for Rescuing and Taking Refuge about the Stairs Space*", Project of Architecture an Building Research Institute, Ministry of The Interior, 2011.
2. Internet information: Fotomore.cn, Chinanews.com, 2010.
3. Statistics data from: Directorate-General of Budget, Accounting and Statistics, Executive Yuan, Taiwan R.O.C., 2010.
4. Statistics data from: Department of Household Registration, Ministry of The Interior, 2010.

5. Statistics data from: National Fire Agency, Ministry of The Interior, 2010.
6. Chiang Chung-Cheng, "*The Characteristics of Taking Refuge and Reality State in Buildings*", Fire-proof Regulation and Safety Design in Buildings Seminar, 1999.
7. Yang Yan-Hong, "*Study of Development conditions of Planning and Construction of the underground street in the city*", Journal of Tianjin Institute of Urban Construction, Vol.14, No.1, Mar 2008.
8. Fire Department, New Taipei City Government, Document No. 0970038705, "*The Project about Fire-prevention Safety Equipment Design in the New Building*", 2008.
9. *The Disaster Prevention White Paper* edited by Ministry of Land, Infrastructure, Transport and Tourism in Japan, Yu Ping 3-year, 1992.
10. Ai Sekizawa, "*Fire Risk Analysis of Cultural Heritages and the Surrounding Areas*", PROGRAM BOOK of 2010 Exchange Meeting for SFPE Asia-Oceania Chapters, pp.1-22, 2010.
11. Chung Kee-Chiang, Chien Jung-chen, Chu Chen-Wei, Chen, Jen-Lang, "*The System of Disaster Prevention in the Large-scale Underground Space*", Chinese Fire Protection Safety Center (CFPSC), 2004.
12. Shih-Yong Lin, Chen Chiun-Hsun, "*The Study on Occupant Evacuation Time Simulations in the Underground Stations*", Master thesis of Mechanical Engineering of National Chiao Tung University, 2011.
13. Hsu tsung-his, Yang yi-yung, "*Disaster Prevention Plan and Taking Refuge Safety Design about Building*", Project of Architecture an Building Research Institute, Ministry of The Interior, 1999.
14. Kevin Kinsella, David R. Phillips, Global Aging, "*The Challenge of Success*", Population Reference Bureau, Vol. 60, No.1, Mar. 2005.
15. Internet information from Disaster Management of Cabinet Office, Government of Japan, http://www.bousai.go.jp/index.html
16. Internet information from Ministry of Land, Infrastructure, Transport and Tourism in Japan, http://www.mlit.go.jp/index.html
17. Internet information from Tokyo, Japan, http://www.metro.tokyo.jp/
18. Chen Prestige, Xiong Guang-Hua, "*A study on emergency response strategies for underground co-constructed spaces of Taipei Main Station*", Master thesis of Graduate Institute of Department of Fire Science of Central Police University, 2008.
19. Jeng Chih-Chiang, Chen Chiun-Hsun, "*A Study on Fire Emergency Response Operation for Underground Station Spaces - Sample as Taipei Main Station*", Master thesis of National Chiao Tung University, College of Engineer, Degree Program of Industrial Safety and Risk Management, 2009.
20. Internet information from: Fire in underground street in Kaoshiung http://139.175.13.20/kmh/oldphoto/findpic.asp?schtype=2&imageKind=d
21. Chang Bang-Lee, Tang Chieh-Hsin, Chang, Shang-Wen, Yen-Ku Kuo, Tseng Shu-Fen, "*The Situation Simulation and Stratagem of Taking Refuge of the Disables in the Large-Scale Underground Space*", Project of Architecture an Building Research Institute, Ministry of The Interior, 2012.

THE STUDY OF JOB STRESS AND EMOTIONAL LABOR

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ABSTRACT

Already become Taiwan support the intersection of significant development and industry of economic system wholly service, as numerous trades stay out of service industry, a large number of manpower has poured into the value chain of the service industry even more.

Pay attention to every manpower resources management topic of service industry seem important to become, manage the intersection of practice and subject circle must focus on.

This research canvasses the relation between working pressure and labor service of the mood of the staff of service industry, through assumption that literature canvass derive, describe the intersection of sample and basic characteristic and become items of person who

*concerned with by narrating statistics, relevant analysis, and then examine each assumption
with structural equation modeling.*

*The working pressure of the service industry of different nature really brings the
influence of the difference. So the complete management system must lighten the staff's
working pressure, and does not look at the industry for appropriate expressing and pressing
and is managed with working properties, can dispel the burden of the labor service of mood
at any time, and then improve the manpower quality of all service industries and create the
high-quality competitiveness.*

Keywords: job stress, emotional labor, structural equation modeling.

INTRODUCTION

The service industry is a major force in Taiwan's economy and show a great deal of power.
Active support for Taiwan's economic growth is an important role. Besides, the high
employment-intensive services sector can provide jobs for the labor market also has a
significant contribution.

Staffs in service industry are the most important human resources; in order to forward the
development of the service sector and the national economy better, need to rely on the service
industry members have been working, so the human resources management in the service
sector is the need to pay attention. If it should enhance the competitiveness of the service
industry in Taiwan to promote good human resource management is the most effective
strategy.

Service workers are busy every day in all areas, a lot of work and responsibility are often
in daily life, even the good work performance, showing excellent performance, but still
generate more job stress and emotional labor, this seems to be a modern service industry
employees cannot escape the question.

This study focuses on understanding the service industry employees work stress and
emotional labor, according to what degree of correlation between the effects and to explore
the context of the theory of structural model, hoping to understand the effects of work stress
on mood employees' labor.

LITERATURE REVIEW AND HYPOTHESIS DEDUCTION

This study describes the theory of job stress and emotional labor, were also the basis for the theoretical explanation and theoretical analysis of the process by inference hypothesis.

Job stress

Robbins & Stephen (2007) believe that individuals face when pressure means a chance to limit, or the dynamics of demand, so that individuals feel uncertain and will affect the outcome of the performance of the individual, the individual's life situations when certain things when not react and cannot adapt to the timely adjustment, will affect the physical and mental.

Working pressure refers to the work environment because some of the characteristics possessed, causing stress for employees, and change practitioners normal physiological or psychological state and circumstances that may affect the performance or health worker. When the work itself requires such as: workload, work challenges, the higher requirements, operating environment, and a variety of occupational safety and health conditions that can cope with more than a situation, will feel the conflict, not pleasant or other changes and produce physical and psychological burden of work pressure.

Pressure often caused adverse effects in several business organizations to individuals or organizations. For individuals, moderate pressure solid individual efforts can contribute to the completion of work on the goal to reach a certain level and self-demanding work. Heavy pressure often makes people feel anxiety and pressure to form a physical illness. For members within the organization, the tedious work that is likely to be one of the sources of stress, especially for achievement motivation strong staff, to accomplish the task often feel anxiety, tension and threat, but everyone objective situational awareness and feel different working pressures are personal and environmental changes on the reaction, the environment itself is uncertain, has become an important source of stress, and therefore "objective circumstances" are becoming pressure, depending on the extent of the individual "subjective perception" may be.

Emotional labor

James(1989) emphasized the emotional labor of others involved in emotional processing, the core elements of emotional rules, from the point of view of the mood at work, emotional labor is a commodity, to promote tend regulate the emotional expression in the public domain, is at work, emotional interaction with others involved in labor work.

Ashforth & Humphrey (1993) defined emotional labor as: appropriate emotional expression of behavior, emphasizing the emotional expression of behavior, rather than emotions to be consistent with the performance of the reaction.

Morris (1995) that the definition of emotional labor is the organization trying to show customers how to manage their employees' emotions, the main goal is to enhance customer satisfaction.

Definition of emotional labor, workers with a high degree of contact with the customer, the customer or the organization to comply with the hopes and expectations, must control their emotions; the main purpose is to maintain a peace of mind for customers, trust expression, and to create a pleasant, bright atmosphere of Service. Customers may contain so-called internal customers: If the company's employees, external customers: If the consumer, workers, trafficking is not only tangible goods, but also covers the service process and customer contact, so the face of the customer, smiling, polite attitude, etc., have become a part of the goods, and customer service-oriented staff, the staff is also considered one of the indispensable traits (Goleman, 1998).

Work stress and emotional labor

In summary, the working pressure of the organization which is more negative state of mind, some sources of work stress may be positive, but much work pressure for staff is overloaded. Competitive business environment employees have more responsibility and burden of emotional labor in the service sector. For the above reasons, this study investigated the relationship is as follows:

Hypothesis: Employees in the service industry work pressure has a positive effect on emotional labor

STUDY DESIGN

The object of this study was selected to serve the employees of the department store industry and the food and beverage industry, from January 2013 until the end of July, the time it lasts six months, and 527 valid samples were collected.

The questionnaire used in this study are: (1) Work Stress Scale (Cavanaugh, 2000); (2) Emotional Labor Scale (Schaubroeck, 2000); these scales are scholars have evolved through

theoretical construct. Relationship as shown in Figure 1.

Figure 1 Research structure

STATISTICAL ANALYSIS

Confirmatory factor analysis (CFA)

To ensure that the questionnaire used in this study has a good reliability and validity, confirmatory factor analysis is used to calculate Composite Reliability (CR) and Average Variance Extracted (AVE), the work pressure that CR is 0.917, AVE is 0.690; emotional labor that CR is 0.879, AVE is 0.549; standardized factor loadings of all items for each question 0.5 above, Squared Multiple Correlation over .25 or more, the convergent validity of standard statistical performance has passed on, as shown in Figure 2.

Figure 2 Confirmatory factor analyses

On the other hand, through the correlation coefficient between the variables of the confidence interval analysis, all range of numbers does not appear to "1", the questionnaire has discriminant validity, as shown in Table 1.

Table 1 Correlation coefficient and confidence interval analysis

Parameter			Estimate	Lower	Upper
Work Stress	<-->	Emotional Labor	0.651	0.574	0.729

Structure Model Analysis

After confirmatory factor analysis to understand the questionnaire both good reliability and validity, and then to test the hypothesis that the overall structure analysis and structural equation modeling fit of all the commonly used indicators to check whether the model fit well, as shown in Figure 3.

Figure 3 Structural model analyses

Bootstrapping was used in this study to test the hypothesis, standardized path coefficient of work pressure affect emotional labor was 0.65 significantly, so the hypothesis was supported, as shown in Table 2.

Table 2 Standardized coefficients and hypothesis testing

Parameter			Estimate	Lower	Upper	P
Emotional Labor	<---	Work Stress	0.651	0.574	0.729	0.001

CONCLUSION

This study investigated the relationship between job stress service and emotional labor, whether with a significant and predictable results, and found work stress and emotional labor is a positive influence verify the hypothesis inference, therefore this study selected subjects in work stress and emotional labor are required for proper reduce stress, it will not affect the quality of work needed services.

Taiwan's service industry has become the economic base and is committed to increasing the number of workers in the service industry. Under the industry supply and demand of human resources management and trade-offs, be sure to pay attention to the sources of stress and emotional burden on internal staff, to avoid focusing on performance but ignores quality services in order to create long-term future prosperity.

REFERENCE

1. Ashforth, B. E., & Humphrey, R. H. (1995). Emotion in the workplace: A reappraisal. *Human relations*, *48*(2), 97-125.
2. Bentler, P. M., & Chou, C. P. (1987). Practical issues in structural modeling.*Sociological Methods & Research*, *16*(1), 78-117.
3. Boyatzis, R. E., Goleman, D., & Rhee, K. (2000). Clustering competence in emotional intelligence: Insights from the Emotional Competence Inventory (ECI).*Handbook of emotional intelligence*, 343-362.
4. Cavanaugh, M. A., Boswell, W. R., Roehling, M. V., & Boudreau, J. W. (2000). An empirical examination of self-reported work stress among US managers.*Journal of Applied Psychology*, *85*(1), 65.
5. Hochschild, A. R. (2003). *The managed heart: Commercialization of human feeling, With a new afterword*. University of California Pr.
6. James, N. (1989). Emotional labour: skill and work in the social regulation of feelings. *The Sociological Review*, *37*(1), 15-42.
7. Morris, J. A., & Feldman, D. C. (1996). The dimensions, antecedents, and consequences of emotional labor. *Academy of management review*, *21*(4), 986-1010.

8. Robbins, S. P., & Langton, N. (2007). *Organizational behaviour: Concepts, controversies, applications*. prentice Hall.

9. Schaubroeck, J., & Jones, J. R. (2000). Antecedents of workplace emotional labor dimensions and moderators of their effects on physical symptoms.*Journal of Organizational Behavior*, *21*(2), 163-183.

MODELLING OPERATIONAL HUMAN RESOURCE MANAGEMENT IN NORDIC HEALTHCARE ORGANIZATIONS

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ABSTRACT

Purpose: Healthcare organizations are under pressure to improve productivity and cut costs. One key element is human resource management, HRM. To evaluate operational HRM practices, it is necessary to have a model of these practices. The purpose of this study is to describe a model of operational HRM in healthcare organizations. The special characteristics of healthcare organizations in the Nordic countries are presented. The model takes these characteristics into account.

Design/methodology/approach: The study is based on literature review on operational HRM and special characteristics of healthcare organizations. The findings in literature review are analyzed in relation to the characteristics of healthcare organizations in the Nordic countries. Also the characteristics themselves are analyzed.

Findings: Model of operational HRM in healthcare organizations is generated. The model is based on general operational HRM and it is developed further to fit to the special characteristics of healthcare organizations. Among other things, the model takes into account professional groups, costs, and software used in HRM in healthcare organizations. This article clarifies the role of operational HRM in healthcare organizations.

Research limitations/implications: The paper is a literature review. The paper is limited to healthcare organizations; however the findings can be applied to other contexts. The model developed in this paper can be used in evaluation of operational HRM in healthcare organizations. Later studies should evaluate the model with empirical studies.

Originality/value: Operational HRM is widely studied research area. However in healthcare organizations operational HRM is not widely studied. In healthcare organizations HRM

studies have focused on productivity instead of, for example, resource allocation. This study clarifies the benefits of well managed operational HRM. Understanding the value of operational HRM in healthcare organizations can result into better productivity, job satisfaction and cost reduction.

Keywords: Healthcare organizations, Literature review, Operational human resource management

Article classification: Literature review

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THE IMPACT OF KNOWLEDGE MANAGEMENT STRATEGY ON INDONESIAN MSMEs' INNOVATION AND PERFORMANCE

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ABSTRACT

Micro, small, and medium enterprises (MSMEs) play a significant role in strengthening the national economy in a worldwide scale. However, in the near future the competition between MSMEs and corporation will be more intense than ever. Therefore, MSMEs need to grow and develop competitive advantages. These advantages could be achieved if the organizations succeed to improve their performance and ability to innovate. This research aims to analyze the relationship among knowledge management (KM) strategy (codification and personalization), innovation and performance in Indonesian MSMEs. The result of this study showed that KM strategy influences SMSEs' innovation both quality and quantity. Our research also showed that KM strategy influences organizational performance, both directly and indirectly through the improvement of innovation.

Keywords: Knowledge Management Strategy, Codification, Personalization, Innovation, Organizational Performance, Micro Small Medium Enterprises (MSMEs)

INTRODUCTION

Worldwide, small and medium-sized enterprises (SMEs) play a significant role in strengthening national economies. They contribute enormously through offering new jobs, increasing technological improvements and competitiveness, and providing more options of services and products (Azyabi et al., 2012). Based on data published by the Ministry of Cooperatives and SMEs of the Republic of Indonesia, one of the greatest contributions of gross domestic product (GDP) in Indonesia comes from micro, small, and medium enterprises

(MSMEs) that is equal to 59.08% of Indonesia's GDP in 2012. The number of micro enterprises in Indonesia is a business unit with the greatest number in 2012, which is 98.79% of the total number of MSMEs in Indonesia (Kemenkop UKM, 2013).

The existence of a large number of MSMEs, which spread to remote regions, is a real economic strength in the national economic structures. MSMEs are able to absorb as many as 90,896,270 people of labour. This indicates that 97.22% of the 93,491,243 number of national employees working in the MSME sector (Kemenkop UKM, 2013). High employment levels have an impact on the labour market stability guarantees, suppress rising unemployment, a rise of new entrepreneurs the means, and the growth of national entrepreneurs and independent.

In the future, competition among MSMEs with large firms will be intense. Therefore, MSMEs should grow up and have a competitive advantage. Competitive advantage can be achieved, one of them through the capability of organization in managing its knowledge (Zack, 1999). Thus knowledge management (KM) is one of the important competitive advantages for a company (Issa and Haddad, 2008).

Zack (1999) states that knowledge as a critical resource and it has encouraged managers to give greater attention to company's knowledge management strategy (KM strategy) (Choi et al., 2007). The study related to the relationship of knowledge management strategies and their impact on MSMEs has not been much done. Therefore, more research on the strategy of knowledge management in SMEs using either a theoretical or a practical point of view is needed (Azyabi et al., 2012). In this study, we aim to test the relationship between knowledge management strategy to quantity and quality of innovation and its impact on the performance of MSMEs in Indonesia.

LITERATURE REVIEW

A. Micro, Small, and Medium Enterprises

According to the World Bank's (Nichter and Goldmark, 2009), a small business is defined as the company that has less than 50 employees, with sales of at least 50% of the entire outputs or products generated by these small businesses. In Indonesia, the MSMEs are governed under the Act No. 20 of 2008 on micro, small and medium enterprises (MSMEs). According to this act, the enterprises are classified as micro, small or medium according to their asset and income as can be seen in Table 1.

Table 1 MSMEs criteria based on asset and income

No.	Classification	Criteria	
		Asset	Income
1	Micro enterprises	≤ 50 million	≤ 300 million
2	Small enterprises	>50 million -500 juta	>300 million- 2,5 billion
3	Medium enterprises	>500 million -10 billion	>2,5 billion - 50 billion

Sources: Act 20 of 2008 Chapter IV of Article 6 (Kemenkop UKM, 2012)

Definition of MSMEs in general is the business that have the capital, income, and relatively small labour (Beesley and Hamilton, 1984), productive and always evolving, in the form of individual businesses and not part of a major businesses (Kemenkop UKM, 2012), and the owner has the freedom to operate their business (Megginson et al., 2006).

B. Knowledge Management Strategy

Beccera-Fernandez (2004) defines knowledge as information that allows the action or decision-making. Knowledge is structured and organized information as a result of cognitive processing and validation (Cooper, 2007). Knowledge can be classified into two types, tacit and explicit (Nonaka, 1994). Choi and Lee (2003) and Keskin (2005), stated that the explicit knowledge has the characteristics easily picked, created, stored, and followed. Tacit knowledge lies in the process or organizational routines, resulting from experience and practice saved through learning by doing certain processes.

Knowledge management is defined as processes required for generating, capturing, codifying, and transfering the knowledge within an organization, so that the organization can gain competitive advantage (Beccera-Fernandez, 2004). Knowledge management can also be defined as the process of managing tacit and explicit knowledge in the organization to improve profitability and competitiveness (Yip et al., 2010).

Beliveau et al. (2011) defined KM strategy as high-level planning that describes and shapes processes, equipment, and infrastructure (including organizational and technological infrastructure) needed to manage various vacancies or excess of knowledge. Yang (2010) defines KM strategy as reflection of a company's competitive strategy to foster dynamic capabilities of the company in creating and transferring knowledge with the goal of providing superior value and meet the growing expectations of clients.

Knowledge management strategy can be classified as codification and personalization strategy based on organizational emphasis on the type of knowledge (explicit and tacit) (Burn et al., 2012). Codification strategy is a "people-to-documents" strategy, which involves the process of securing explicit knowledge in the form of a database so that others can access and use it back easily (Hansen, Nohria, & Tierney, 1999). Personalization strategy is a knowledge management strategy based on a "person-to-person" by providing customized services. This strategy focuses on discussions among individuals, rather than on the knowledge stored in the database (Greiner, Böhmann, & Krcmar, 2007).

C. Innovation and Organizational Performance

Davenport (2006) suggested that innovation is a wide concept and there are five different types of innovation, which is product innovation, service innovation, process innovation, managerial innovation, and business model innovation. Innovation can be seen from the point of view innovation speed and innovation quality, these differences are described in Wang and Wang (2012). Innovation speed is defined as the time elapsed between (a) initial development (including the conception and definition of an innovation) and (b) ultimate commercialization of a new product or services into the marketplace. It reflects a firm's capability to accelerate activities and tasks for building a competitive advantage relative to its competitors within industries with shortened product life cycles (Allocca and Kessler, 2006).

Innovation quality is defined through variables like amount, effectiveness, features, reliability, timing, costs, complexity, innovation degree, value to the customer, and many more. The concept of innovation quality allows making a statement regarding the aggregated innovation performance in every domain within an organization by comparing the result, being it a product, process or service innovation, with the potential and considering the process on how these results have been achieved (Haner, 2002; Lanjouw and Schankerman, 2004).

According to Daft (2000), the performance of an organization is the ability of an organization to achieve its objectives by using its resources effectively and efficiently. Ricardo & Wade (2001) argued that the performance should have a broader base, include effectiveness, efficiency, economy, quality, consistency and measurement of normative behaviour. As seen in the literature, all of the organization's performance about achievement goals, while the organizational goals can be financial (such as profit making) and non-financial (such as spreading awareness on a particular community). Thus, organizational performance can be categorized into two, financial and non-financial.

HYPOTHESES AND RESEARCH MODEL

This study aims to determine the relationship and impact of knowledge management strategy on innovation and performance of MSMEs. The proposed research model can be seen in Figure 1.

Figure 1 Hypotheses and research model

A. The Impact of KM Strategy On Innovation

The existence of a positive relationship between KM strategy and innovation performance (Darroch, 2005; Lee, 2004; Chang and Lee, 2007) shows that better knowledge management practice will improve the innovation performance within the organization. MSMEs are businesses that have high flexibility, have limited knowledge, serve small markets, and engage in intense competition. However, these conditions still allow MSMEs to innovate to survive in the fierce competition, as long as they can manage their knowledge and resources.

Companies that focus on the use of codification strategy will lead to innovation in product Liao (2007). Codification is needed for radical innovation (Majchrzak et al., 2004). Personalization strategy enables the development of innovation (Swan et al., 1999). It can be concluded that both codification and personalization can increase the company's innovation. Wu and Lin (2009) also supported by stating that personalization increases the quality and ability to innovate. Therefore, we propose the following hypotheses:

- *H1a: codification strategy has positive relationship to the quality of innovation.*
- *H1b: codification strategy has positive relationship to the speed of innovation.*
- *H2a: personalization strategy has positive relationship to the quality of innovation.*
- *H2b: personalization strategy has positive relationship to the speed of innovation.*

B. The Impact of KM Strategy on Organizational Performance

In order to compete, SMEs need a variety of knowledge to develop and improve effectiveness, efficiency and productivity. The existence of a positive relationship between KM strategy with the company's performance has been known previously (Keskin, 2005; López-Nicolás and Meroño-Cerdán, 2011; Rahim et al., 2012). The management of codified knowledge can save time (Ofek and Sarvary, 2001; Haas and Hansen, 2007) and improve coordination efforts (Wu and Lin, 2009). Moreover, personalization strategy can improve the quality (Ofek and Sarvary, 2001), increase the competence signal to the clients (Haas and Hansen, 2007) and improve the ability to innovate (Wu and Lin, 2009).

Thus, by using both personalization and codification knowledge management strategy, SMEs are expected to be able to achieve maximum performance to continue to grow and compete with other companies. Therefore, we posit the following hypotheses:

- *H3a: Personalization strategy has positive relationship to financial performance.*
- *H3b: Personalization strategy has positive relationship to operational performance (non-financial).*
- *H4a: Codification strategy has positive relationship to financial performance.*
- *H4b: Codification strategy has positive relationship to operational performance (non-financial).*

C. The Impact of Innovation on Organizational Performance

In the Wang and Wang (2012), it is known that the organization will get benefit from the increasing of ideas and more innovative human resources in the form of more effective company's performance achievement. Innovation has been recognized as an important supporting factor for the company in creating value and maintaining a competitive advantage in a rapidly changing and complex environment (Bilton and Cummings, 2009; Subramaniam and Youndt, 2005). Innovation became an important part to achieve efficiency of way of working and to enhance the service quality (Hsueh and Tu, 2004; Parasuraman, 2010).

López-Nicolás and Meroño-Cerdán (2011) stated that innovation has a positive impact on the financial and operational performance. Research of Vaccaro et al. (2010) also showed that there is a direct and indirect relationship between the knowledge management to financial performance through the increase of innovation. The similar finding also was found by Yang (2010). Therefore, we propose the following hypotheses:

- *H5a: Innovation quality has a positive impact on the financial performance.*
- *H5b: Innovation quality has a positive impact on the operational performance (non-financial).*
- *H6a: Innovation speed has a postive impact on financial performance.*
- *H6b: Innovation speed has a postive impact on operational performance (non-financial).*

METHODOLOGY

D. Population, Sample, and Data Collection Procedures

The research instrument has been tested through readability test to 10 owners of MSMEs in one of the largest craft fairs event in Indonesia (INACRAFT 2013) which was held on 25 April 2013 at the Jakarta Convention Center. We also asked 10 MSME owners who are twitter user to test the readability of our research instrument.

Respondents in this study were taken from the trading board website of the Ministry of Cooperatives and MSMEs and from the www.seputarUKM.com website. In total, there are 4503 MSMEs listed on both websites. We only selected MSMEs that have electronic mail or a cell phone number, thus resulting as many as 1723 MSMEs. The data was collected by sending online questionnaires that have been made through e-mail and short message (SMS).

E. Research Instruments

In this study, explicit oriented KM strategy or codification was measured using four indicators from the Choi and Lee (2003), which has been adopted by several researchers. Tacit oriented KM strategy or personalization was measured using four indicators from the Choi and Lee (2003).

Innovation speed is measured using five indicators from Liao et al. (2010). Innovation quality is measured using five indicators developed by Haner (2002) and Lahiri (2010). Financial performance was measured using four indicators from the Claycomb et al. (1999) and Inman et al. (2011). Operational performance was measured using six indicators from Wang and Wang (2012).

The instrument was developed by using 5 points likert scale. 1 indicates that respondent is strongly disagree with our statement, whereas 5 indicates that the respondent is strongly agree with our statement.

RESULTS AND DISCUSSION

Of the 1723 questionnaires that were distributed, 206 respondents completed the questionnaire, yielding response rate at 12%. This amount is sufficient to conduct the statistical processing using structural equation modelling (SEM) with the help of LISREL 8.8 applications, SPSS, and Microsoft Excel.

F. Measurement Model Testing

We used the confirmatory factor analysis (CFA) to test the validity, reliability, and suitability of measurement model. The validity test was conducted by examining the t-value and the standardized loading factor (SFL) of each indicator. The t-value should have value ≥ 1.96 (greater than or equal to 1.96), and the standardized loading factor (SFL) should have value ≥ 0.50 (greater than or equal to 0.50) (Wijanto, 2008). Reliability test was done by calculating the value of Construct Reliability (CR) and Variance Extracted (VE) of the values of the standardized loading factors and error variances. López-Nicolás and Meroño-Cerdan (2011) noted that the value of CR should be above 0.70, as recommended by other studies, and VE above 0.50.

The validity showed that the t-value of all indicators ≥ 1.96 and the standardized loading factor value of all indicators ≥ 0.5. The reliability test showed that all variables have a value of CR ≥ 0.7 and VE ≥ 0.5 except for Per_stra (personalization strategy) that has a value of VE < 0.5. However we still include the Per_stra variable considering its CR > 0.7. The complete test results can be seen in Table 2.

The measurement model fit test results also showed good results with the normed Chi-square value (1.822), RMSEA (0.064), NFI (0.96), NNFI (0.98), CFI (0.98), GFI (0, 82), and SRMR (0.051). Thus the results of CFA conclude that our instrument is valid and reliable so that further structural testing can be done.

G. Structural Model Testing

In order to test the structural model, we used Normal Chi-square, RMSEA, NFI, NNFI, CFI, GFI and SRMR as goodness of fit criteria.

The initial value of compatibility test results are Normed Chi-Square (2.448), RMSEA (0.082), NFI (0.94), NNFI (0.96), CFI (0.97), GFI (0.78), and SRMR (0,12). The results can be categorized as less good, therefore the model is modified by the addition of error covariance which significantly influence the compatibility value of each criterion. Table 3 shows the test results of the structural model fit after modification of the structural model.

Compatibility test results of each criterion are good, except for GFI and SRMR which are less good. However, based on Hu and Bentler (1999) and Green et al. (2006), SRMR values < 0.8 can be considered as good fit. Moreover, Seyal et al. (2002) in the Hsu and Lu (2004) states that in practice, the value of GFI > 0.8 is still can be considered as a good fit. Therefore, it can be concluded that the overall results of the research model has good fit values
.

Table 2 Results of validity and reliability of instrument

Variable	Validity			Reliability	
	T-value	SLF	SLF Error	CR	VE
Cod_str (*Codification Strategy*)				0,858	0,603
CS1	12,5	0,79	0,38		
CS2	10,85	0,71	0,49		
CS3	11,62	0,75	0,44		
CS4	13,9	0,85	0,28		
Per_str (*Personalization Strategy*)				0,788	0,484
PS1	10,6	0,73	0,47		
PS2	10,76	0,73	0,46		
PS3	10,45	0,72	0,48		
PS4	8,23	0,59	0,65		
In_spe (*Innovation Speed*)				0,910	0,670
IS1	14,58	0,85	0,27		
IS2	14,08	0,84	0,3		
IS3	13,92	0,83	0,31		
IS4	13,09	0,8	0,37		
IS5	12,5	0,77	0,4		
In_qua (*Innovation Quality*)				0,927	0,718
IQ1	14,85	0,86	0,26		
IQ2	14,43	0,85	0,28		
IQ3	15,12	0,87	0,24		
IQ4	14,92	0,86	0,25		
IQ5	12,9	0,79	0,38		
Fin_per (*Financial Performance*)				0,932	0,775
FP1	15,13	0,87	0,24		
FP2	16,8	0,93	0,14		
FP3	14,08	0,83	0,31		
FP4	15,62	0,89	0,21		
Opr_per (*Operational Performance*)				0,911	0,632
OP1	12	0,75	0,44		
OP2	12,75	0,78	0,39		
OP3	12,46	0,77	0,41		
OP4	14,63	0,86	0,27		
OP5	13,19	0,8	0,36		
OP6	13,52	0,81	0,34		

H. Discussion and Implication

Analysis of the causal relationship is done by looking at the t-value and the determination coefficient. If the t-value on structural equation ≥ 1.96, then it means that the coefficient of structural equation is significant and the hypothesis can be accepted. The determination coefficient (R^2), shows how much variation of the dependent variable that can be explained by the independent variables (Wijanto, 2008).

Table 3 Test results of structural model fitness

Criteria	Standard	Estimation result	Fitness level
χ^2/df	< 2	1,858	*Good Fit*
RMSEA	$\leq 0,08$	0,065	*Good Fit*
NFI	$\geq 0,9$	0,96	*Good Fit*
NNFI	$\geq 0,9$	0,98	*Good Fit*
CFI	$\geq 0,9$	0,98	*Good Fit*
GFI	$\geq 0,9$	0,82	*Marginal Fit*
SRMR	$\leq 0,05$	0,056	*Marginal Fit*

Figure 2 Test results of a causal relationship between variables (*t-value*)

Figure 2 shows that both codification and personalization strategy influence directly and indirectly financial and operational performance. The codification strategy proves to influence directly both quality and quantity of innovation and financial performance. The personalization strategy proves to influence indirectly both financial and operational performance through the mediating role of innovation speed.

Table 4 Significance of causal relationships between variables after modification of models and hypothesis testing results

Hypothesis	Standard	t-value	Conclusion	Result
H1a	$\geq 1,96$	4,4	Significant	Accepted
H1b	$\geq 1,96$	3,24	Significant	Accepted
H2a	$\geq 1,96$	1,15	Not Significant	Rejected
H2b	$\geq 1,96$	2,62	Significant	Accepted
H3a	$\geq 1,96$	-2,26	(-) Significant	Rejected
H3b	$\geq 1,96$	-0,68	Not Significant	Rejected
H4a	$\geq 1,96$	2,56	Significant	Accepted
H4b	$\geq 1,96$	0,99	Not Significant	Rejected
H5a	$\geq 1,96$	0,63	Not Significant	Rejected
H5b	$\geq 1,96$	2,17	Significant	Accepted
H6a	$\geq 1,96$	2,67	Significant	Accepted
H6b	$\geq 1,96$	3,45	Significant	Accepted

Table 4 shows that the innovation quality is significantly affected by the codification strategy. Codification strategy has a greater positive impact on the innovation speed when compared with the personalization strategy. Our finding supports Liao (2007) that stated that if the company focus on the use of codification strategy, it will lead to innovation in products.

The results of this study reveal some finding which are opposed to the theory and previous research. Only the codification strategy that has significant direct relationship with financial performance. The operational performance is not affected directly by both the codification strategy and personalization strategy. MSMEs may not have a formal and explicit knowledge management strategy (Beijerse, 2000). The MSMEs may conduct the knowledge management practices, but they may does not recognize it (Skyrme, 2002). Thus, the possibility of the existence of a knowledge management strategy is considered no effect on performance and not recognized by the owners of MSMEs.

Operational performance is significantly affected by the innovation quality and innovation speed, whereas financial performance is only significantly influenced by the innovation speed. The impact of innovation speed on financial and operational performance is in line with the results of Wang and Wang (2012). Innovation quality affect operational performance, in contrast to the findings of Wang and Wang (2012) which states that the innovation quality affect financial performance. Our results are also consistent with the results of López-Nicolás and Meroño-Cerdan (2011) which stated that innovation has a positive impact on the financial and operational performance.

The relationship between innovation with performance, and the relationship between KM strategy with innovation shows that there is no direct relationship of KM strategy on the performance of the MSMEs as shown in Table 9. These results confirm the importance of innovation as the mediating variable of KM strategy and organizational performance. Yang (2010) also predicted that the relationship between KM strategy with performance will be positive if the innovation process is high.

Table 5 Indirect influence of KM strategy in performance through the intermediary of innovation

Path	Estimates	Conclusion
Cod_str --> In_qua --> Fin_per	-	No
Cod_str --> In_spe --> Fin_per	0,23	Influential
Cod_str --> In_qua --> Opr_per	0,242	Influential
Cod_str --> In_spe --> Opr_per	0,322	Influential
Per_str --> In_qua --> Fin_per	-	No
Per_str --> In_spe --> Fin_per	0,2	Influential
Per_str --> In_qua --> Opr_per	-	No
Per_str --> In_spe --> Opr_per	0,28	Influential

The results of the study about the relationships of knowledge management strategy, innovation and performance can be a guide for MSME owners in Indonesia in selecting a knowledge management strategy. MSME owners can also use this research as a consideration material to improve the performance and innovation of the company using the KM strategy. Recommendations can be given to MSMEs in Indonesia from the results of this study are SMEs should focus more on the use of codification strategy rather than personalization. Moreover, MSMEs are advised to use information technology or information systems in the implementation of codification strategy, to store, share, and get back a formal knowledge so that the management process of knowledge becomes easier. The use of information technology also proved to improve Indonesian MSMEs performance (Cofriyanti and Hidayanto, 2013).

Indonesian government in this case the Ministry of Cooperatives and MSMEs can use this research finding to improve the quality of Indonesian MSMEs by assisting MSMEs in implementing the codification strategy, such as providing assistance/information technology facilities. The government should also provide knowledge in codified (written) forms so as to be easily accessed by MSMEs.

Furthermore, the results of this research can be further developed in more depth to determine the influence of KM strategy to innovation and performance when viewed from various processes such as the knowledge discovery, knowledge creation, knowledge sharing, and

knowledge application or SECI approach (socialization, externalization, combination, and Internalization).

CONCLUSION

The results of this study proves the influence of innovation as an intermediary of KM strategy to improve MSMEs' performance. Codification has indirect effect on operational performance through increasing of the innovation speed and quality. Codification also indirectly affects the financial performance through increasing of innovation speed, whereas personalization indirectly affects the financial and operational performance through increasing of innovation speed. Codification has greater indirect effect on operational and financial performance through increasing of innovation speed when compared with personalization.

REFERENCES

1. Allocca, M.A., & Kessler, E.H. (2006). Innovation Speed in Small and Medium Sized Enterprises. Creativity and Innovation Management, Vol. 15, Iss. 3, pp. 279–295.
2. Azyabi, N., Fisher, J., Tanner, K., & Gao, S. (2012). Developing A Theoretical Framework for Knowledge Management Strategic Orientation Among SMEs. PACIS 2012 Proceedings, paper 36. Available at (http://aisel.aisnet.org/ pacis2012/36), accessed 15 March 2013.
3. Beccera-Fernandez, I. (2004). Knowledge Management: Challenge, Solutions, and Technologies. New Jersey: Pearson Prentice Hall.
4. Beesley, M.E., & Hamilton, R.T. (1984). Small Firm's Seedbed Role and the Concept of Turbulence?. The Journal of Industrial Economics, Vol. 33, Iss. 2, pp. 217-231.
5. Beijerse, U.R.P. (2000). Knowledge Management in Small and Medium-Sized Companies: Knowledge Management for Entrepreneurs. Journal of Knowledge Management, Vol. 4, No. 2, pp. 162-179.
6. Beliveau, B., Bernstein, E.H., & Hsieh, H.J. (2011). Knowledge Management Strategy, Enablers, and Process Capability in U.S. Software Companies. Journal of Multidisciplinary Research, Vol. 3, No. 1, pp. 25-46.
7. Bilton, C., & Cummings, S. (2009). Creative Strategy: From Innovation to Sustainable Advantage. John Wiley & Sons Ltd.
8. Burn, N.A., Din, S., Ng, A.H.H., & Yip, M.W. (2012). Integrated Knowledge Management Strategy: A Preliminary Literature Review. Procedia - Social and Behavioral Sciences, Vol. 57, pp. 209-214.
9. Chang, S.C., & Lee, S.M. (2007). The Effects of Organizational Culture and Knowledge Management Mechanism on Organizational Innovation: An Empirical Study in Taiwan. The Business Review Cambridge, Vol. 7, No. 1, pp. 295-301.

10. Choi, B., & Lee, H. (2003). An Empirical Investigation of KM Styles and Their Effect on Corporate Performance. Information and Management, Vol. 40, No. 5, pp. 403-417.

11. Claycomb, C., Dröge, C., & Germain, R. (1999). The Effect of Just-In-Time with Customers on Organizational Design and Performance. International Journal of Logistics Management, Vol. 10, Iss. 1, pp. 37–58.

12. Cooper, P. (2007). Knowledge Management. Anaesthesia & Intensive Care Medicine, Vol. 8, Iss. 12, pp. 516-517.

13. Cofriyanti, E. & Hidayanto, A. N. (2013). The Relationship among Organizations' Factors, Information Technology, Innovation and Performance: An Indonesian SMEs Study. International Journal of Innovation and Learning, Vol. 14, No. 3-4, pp. 422-443

14. Daft, R.L.(2000). Organization Theory and Design (7th ed.). Thomson Learning. U.S.A: South-Western College Publishing.

15. Darroch, J. (2005). Knowledge Management, Innovation and Firm Performance. Journal of Knowledge Management, Vol. 9, No. 3, pp. 101-115.

16. Davenport, T. (2006). The Different Domains of Innovation. Babson Insight.

17. Green, J.L., Camilli, G., & Elmore, P.B. (2006). Handbook of Complementary Methods in Education Research. Washington, D.C.: American Educational Research Association.

18. Greiner, M.E., Böhmann, T., & Krcmar, H. (2007). A Strategy for Knowledge Management. Journal of Knowledge Management, Vol. 11, No. 6, pp. 3-15.

19. Haas, M., & Hansen, M. (2007). Different Knowledge, Different Benefits: Toward a Productivity Perspective on Knowledge Sharing in Organizations. Strategic Management Journal, Vol. 28, No. 11, pp. 1133–1153.

20. Haner, U.E. (2002). Innovation Quality-A Conceptual Framework. International Journal of Production Economics, Vol. 80, No. 1, pp. 31–37.

21. Hansen, M.T., Nohria, N., & Tierney, T. (1999). What's Your Strategy for Managing Knowledge. Harvard Business Review, Vol. 77, No. 2, pp. 106-116.

22. Hsu, C.L., & Lu, H.P. (2004). Why Do People Play Online Games? An Extended TAM with Social Influences and Flow Experience. Information & Management, Vol. 41, No. 7, pp. 853-868

23. Hsueh, L., & Tu, Y. (2004). Innovation and The Operational Performance of Newly Established Small and Medium Enterprises in Taiwan. Small Business Economics, vol. 23, No. 2, pp. 99–113.

24. Hu, L.T., & Bentler, P.M. (1999). Cutoff Criteria for Fit Indices in Covariance Structure Analysis: Conventional Criteria Versus New Alternatives. Structural Equation Modeling, vol. 6, Iss. 1, pp. 1–55

25. Inman, R.A., Sale, R.S., Green, K.W.Jr, & Whitten, D. (2011). Agile Manufacturing: Relation to JIT, Operational Performance and Firm Performance. Journal of Operations Management, Vol. 29, No. 4, pp. 343–355.

26. Issa, R.R., & Haddad, J. (2008). Perceptions of The Impacts of Organizational Culture and Information Technology on Knowledge Sharing in Construction. Construction Innovation: Information, Process, Management, Vol. 8, Iss. 3, pp. 182 - 201.

27. Kementerian Koperasi dan UKM (Kemenkop UKM). (2012). Undang-undang Nomor 20 Tahun 2008 Tentang KUKM - Penjelasan. Available at (http://www.depkop.go.id/index.php?option=com_ phocadownload&view=file&id=210:undang-undang-nomor-20-tahun-2008-tentang-kukm-penjelasan&Itemid=93) , accessed 5 April 2013.

28. Kementrian Koperasi dan UKM (Kemenkop UKM). (2013). Perkembangan Data Usaha Mikro, Kecil, Menengah (UMKM) dan Usaha Besar (UB) Tahun 2011–2012. Available at (http://www.depkop.go.id/ index.php?option=com_phocadownload&view=category&id=118:data-umkm-2013&Itemid=93), accessed 15 March 2013.

29. Keskin, H. (2005). The Relationships Between Explicit and Tacit Oriented KM Strategy, and Firm Performance. Journal of American Academy of Business, Cambridge, Vol. 7, No. 1, pp. 169–75.

30. Lahiri, N. (2010). Geographic Distribution of R&D Activity: How Does It Affect Innovation Quality. The Academy of Management Journal (AMJ), Vol. 53, No. 5, pp. 1194–1209.

31. Lanjouw, J.O., & Schankerman, M. (2004). Patent Quality and Research Productivity: Measuring Innovation with Multiple Indicators. The Economic Journal, Vol. 114, No. 495, pp. 441–465.

32. Lee, C. (2004). The Determinants of Innovation in The Malaysian Manufacturing Sector: An Econometric Analysis at The Firm Level. Center on Regulation and Competition, Working Paper Series.

33. Liao, C.C., Wang, H.Y., Chuang, S.H., Shih, M.L., & Liu, C.C. (2010). Enhancing Knowledge Management for R&D Innovation and Firm Performance: An Integrative View. African Journal of Business Management, Vol. 4, No. 14, pp. 3026–3038.

34. Liao, Y.S. (2007). The Effects of Knowledge Management Strategy and Organization Structure on Innovation. International Journal of Management, Vol. 24, No. 1, pp. 53-60.

35. López-Nicolás, C., & Meroño-Cerdán, A.L. (2011). Strategic Knowledge Management, Innovation and Performance. International Journal of Information Management, Vol. 31, No. 6, pp. 502–509.

36. Majchrzak, A., Cooper, L.P., & Neece, O.E. (2004). Knowledge Reuse for Innovation. Management Science, Vol. 50, No. 2, pp. 174–188.

37. Megginson, L.C., Byrd, M.J., & Megginson, W.L. (2006). Small Business Management: An Entrepreneur's Guidebook, 3rd Edition. United States of America: McGraw-Hill.

38. Nichter, S., & Goldmark, L. (2009). Small Firm Growth in Developing Countries. World Development Report, Vol. 37, Iss. 9, pp. 1453-1464.

39. Nonaka, I. (1994). A Dynamic Theory of Organizational Knowledge Creation. Organization Science, Vol. 5, Iss. 1, pp. 14-37.
40. Ofek, E., & Sarvary, M. (2001). Leveraging The Customer Base: Creating Competitive Advantage through Knowledge Management. Management Science, Vol. 47, No. 11, pp. 1441–1456.
41. Parasuraman, A. (2010). Service Productivity, Quality and Innovation: Implications for Service-Design Practice and Research. International Journal of Quality and Service Sciences, Vol. 2, Iss. 3, pp. 277–286.
42. Rahim, R.A., Salleh, N.F., Ahmad, S.F.S., & Kassim, R.S.R. (2012). The Relationship Between Knowledge Management Strategies and Innovation Performance Among Electronics, Foods and Beverages Organizations. International Conference on Innovation Management and Technology Research (ICIMTR), pp. 112-117.
43. Ricardo, R., & Wade, D. (2001). Corporate Performance Management: How to Build A Better Organization Through Measurement Driven Strategies Alignment. Butterworth Heinemann.
44. Seyal, A., Rahman, M., & Rahim, M. (2002). Determinants of Academic Use of The Internet: A Structural Equation Model, Behaviour and Information Technology, Vol.21, No. 1, pp.71–86
45. Skyrme, D. (2002). Knowledge Management: Approaches and Policies. Paper on Policy Issues Affecting Small and Medium Sized Enterprise in Europe. Available at (http://www.providersedge.com/docs/ km_articles/KM_-_Approaches_and_Policies.pdf) , accessed 25 March 2013.
46. Subramaniam, M., & Youndt, M.A. (2005). The Influence of Intellectual Capital on The Types of Innovative Capabilities. Academy of Management Review, vol. 48, pp. 450–463.
47. Vaccaro, A., Parente, R., & Veloso, F.M. (2010). Knowledge Management Tools, Interorganizational Relationships, Innovation and Firm Performance. Technological Forecasting & Social Change, Vol. 77, No. 7, pp. 1076–1089.
48. Wang Z., and Wang, N. (2012). Knowledge Sharing, Innovation and Firm Performance. Expert Systems with Applications: An International Journal, Vol. 39, Iss. 10, pp. 8899-8908.
49. Wijanto, S. (2008). Structural Equation Modeling dengan Lisrel 8.8: Konsep dan Tutorial. Graha Ilmu.
50. Wu, I., & Lin, H. (2009). A Strategy-Based Process for Implementing Knowledge Management: An Integrative View and Empirical Study. Journal of The American Society for Information Science and Technology, Vol. 60, No. 4, pp. 789–802.
51. Yang, J. (2010). The Knowledge Management Strategy and Its Effect on Firm Performance: A Contingency Analysis. International Journal of Production Economics, vol. 125, issue 2, pp. 215-223. Yang, J. (2010). The Knowledge Management Strategy and Its Effect on Firm Performance: A Contingency Analysis. International Journal of Production Economics, Vol. 125, Iss. 2, pp. 215-223.

52. Yip, M.W., Lau, H.C., & Songip, A.R. (2010). Influence of Soft Elements on Knowledge Management Implementation in Malaysia Higher Learning Institutions. Journal of Knowledge Management Practice, Vol. 11, No. 3.

53. Zack, M.H. (1999). Developing A Knowledge Strategy. California Management Review, Vol. 41, No. 3, pp. 125–145.

PRODUCTIVITY AND QUALITY OF WORK LIFE: IMPLICATIONS FROM COST CONTAINMENT INITIATIVES

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ABSTRACT

The study aims to provide the systematic feedback reflecting the productivity level for the company's new management team (presiding over the off-shore oil and natural gas operations). This feedback is important due to a series of the 2009 decisions aimed to contain and reduce labor costs. Given the work stoppages, and the ill-feeling from contracted worker, the study is proposed to evaluate the interrelationships between quality of work life and productivity. The study applies the applications of the Multi Criteria Productivity/performance Technique and statistical analyses. The overall level of productivity is affected by quality of work life. In addition, without an improvement in quality of work life for contracted workers and labor productivity, the company's productivity will decline over time. Finally, the significant implication is that, instead of labor cost, the focus should now be on the operating cost.

INTRODUCTION

Generally, productive operations require continuous investment in technology, effective communication within and outside an organization, and motivated workforce (Andersen *et al.*, 2004; Steiner, 2008; and Fasil and Osada, 2011). Despite the fact that the use of automation and information technology has reduced the importance of workforce; certain technical operations such as repair, maintenances, inspection, exploration, and drilling still rely on knowledge, skills, and motivation of the workers (Dobni, 2011; and Arora and Arora

2013). In addition, knowledge-intensive services such as research and development, customer relations, new product development cannot simply overlook workers' contributions. In fact, Sink (1985), and Sink and Tuttle (1989) stated that the level of organizational and operational productivity was influenced greatly by individuals' attitude, motivation, skills, and knowledge. The way the individuals would respond to their tasks and assignments represented the consequences of how well they felt about the workplace. In other words, it is important to recognize and understand that the overall performance level, especially productivity, is greatly influenced by the workforce (Dixon *et al*., 1990; Kathuria *et al*., 2010; and Ropret *et al*., 2012).

Productivity is defined as the relationship between outputs from and inputs into a system. Productivity can be measured from single-, multiple-, and total-factor perspectives (Sink, 1985 and Terziovski, 2006). Single measures include the relationship between outputs and labor, materials, or facility space. The multiple measures are, for example, the relationship between outputs and labor plus materials. The total factor measures include all possible inputs into a system. In summary, the inputs include labor (human resources), capital (physical and financial capital assets), energy, material, and data that are brought into a system. These resources are then transformed into the outputs that will be used for customer usages and sales.

Simply put, productivity is defined as outputs divided by inputs (Barnes, 1980; and Sink, 1985). It has always been recognized this way since the term was first mentioned in the late 1800s. This is reaffirmed by many international agencies such as American Productivity and Quality Center and Asian Productivity Organization. In fact, in 1950, the Organization for European Economic Cooperation, now known as Organisation for Economic Cooperation and Development or OECD, formally stated a definition of productivity as a ratio of an output divided by one or more production factors. The outputs represent products and goods (and later services) as well as some undesirable ones such as rejects and wastes generated. On the other hand, the inputs include key resources used for this generation such as labors, materials, and machines, and electricity and water.

Instead of independently and separately focusing on the input and output sides, productivity represents a major philosophical shift in how a work system (including a workstation, an assembly line, a process, and a plant) should be analyzed for continuous improvement. When dividing the outputs by the inputs, the information shows how well the resources are utilized in order to generate the outputs. A firm's unit cost is maintained and reduced as a result of productivity improvement. At the industrial and national levels, productivity has significant implications on cost competitiveness of a country (Sumanth, 1985).

Sink and Tuttle (1989) described individuals' attitude and motivation in the workplace as quality of work life (QWL). The QWL is defined as the feeling of the workers toward an organization, based on several attributes such as pay and compensation; working conditions

and environment; relationships with co-workers, subordinates, and supervisors; skills and knowledge readiness for task requirements; and so on (Sink and Tuttle, 1989; and Korunka *et al*., 2008). Previous studies have shown that the QWL can result in negative impacts on a firm's operations and overall performance. Gradually, poor QWL can lead to slowdown in production and operations, and subsequently attention to work details (i.e., quality) as well as process innovation (Kathuria *et al*., 2010). The continuation of poor QWL will further lead to lateral transfer and even damaged and stolen properties. Eventually, dismissal and turnover will take place. Turnovers of skilled workforce can be very expensive for identifying suitable replacement, and disruptive for operational continuity. Losing skillful staffs means that additional costs associated with recruiting and training and skill development will take place (Deming, 1986; and Lakhal *et al*., 2006).

Finally, both QWL and productivity are basically part of the performance in which an organization needs to measure and evaluate (Sink and Tuttle, 1989). In their viewpoint, there were a total of seven aspects of the term performance. Others are profitability, innovation, quality, effectiveness, and efficiency. The attribute to become more profitable is productivity while impacts from productivity stem from QWL and other remaining performance criteria. In other words, it is suggested that improvement QWL can either explicitly and or implicitly increase organizational and operational productivity. Measuring the entire performance spectrum can further help communicate policy initiatives, monitor and evaluate their impacts, and formulate possible changes to ensure continuous improvement (Yeniyurt, 2003; and Laitinen, 2009).

CASE COMPANY BACKGROUND

The case company operates in the areas of oil and gas exploration, and has several sites in the region. The company earlier received a concession from the Royal Thai Government for off-shore explorations in Gulf of Thailand. Due to the pressure for cost control and containment, a case company has implemented many initiatives that deal with this pressure. Given the fact that a new management team was in place (as of July 2011), the evaluation on the desirable impacts was urged by the re-created welfare committee in the early 2012. Therefore, the study was suggested and later approved to learn more on the impacts from previous initiatives on cost containment and reduction initiatives on the QWL and productivity levels. The results from this study would provide useful information on the impacts from past managerial decisions' impacts and a possibly next round of cost reductions as the conflicts and poor atmosphere became more apparent.

Before the arrival of a new management team, work slowdowns and stoppages had taken place which resulted in project delays and cost overrun. One of the key decisions was to introduce the term contracted workers. These workers had earlier been a company staffs but were asked to resign. Then, they were immediately rehired for the same work. This strategy aimed to relieve the company from complying and adhering to the labor regulations while

saving the labor costs, especially in the fringe benefits. Several projects aimed to boost output capacity had failed to achieve the company's goal of the 20% increase in profits. Other past decisions relating to labor practices included the cap in salary increase, the reduction in fringe benefits and medical compensation, and the abolition of the joint welfare committee(between labor ad management team).

One of the company's earliest decisions to contain cost was to reduce the proportion of workers assigned to off-shore operations relative to contracted workers. In other words, more contracted workers would perform most tasks and work. This is due to the fact that the tasks on the off-shore exploration platform were identical. This decision responded to rising insurance and health-related costs as well as the risk for lawsuits and other legal implications as a result of accidents by company employees. Initially, the pay scale and compensation on overtime work were by and large the same, except for insurance costs and an ability to file safety-related lawsuits.

The more stringent policy on cost containment began in 2010. More drastic initiatives were announced in the following sequence. Some of the key decisions that directly relate to contracted workers can be summarized as follows.

- February 2010: Cost reduction policy and plans were officially launched.
- March 2010: Wage control (freeze) for the 3-year period was announced.
- May 2010: Reduction on the contribution to external fund support for staff retirement was adopted.
- June 2010: Reduction on per-diem allowance was adopted.
- July 2010: Change in overtime-payment calculation was implemented.
- September 2010: Reduction on a company's payments to an insurance firm for healthcare coverage was adopted. The change in travel reimbursement calculation was implemented.
- October 2010: Reduction of retirement age from 60 to 55 years old was adopted. The welfare committee (constituting union leaders from contracted workers and company management) was abolished.
- November 2010: Reduction for on-shore breaks was adopted. The reduction for company-paid or –sponsored training days was announced.

OBJECTIVES

The primary objective of this study is to analyze and evaluate the impacts from the initiatives relating to cost containment and reduction on the QWL and productivity levels. A lack of information sharing and a mechanism to monitor and evaluate the impacts from the labor-related decision was cited as the reason for the breakdown in the welfare committee. Three issues were raised and would be evaluated. Was the overall productivity level affected by labor productivity? Was the overall level of productivity is impacted by QWL from either

employees or contracted workers? Had the time-lag impacts played any role in influencing the overall productivity level?

METHODOLOGY

There were several steps taken for the completion of this study. The first step was to identify suitable key performance indicators (KPIs) or measures reflecting the QWL and productivity levels. This step was completed jointly between staffs and new management team. The second step was to employ the Multi Criteria Productivity/performance Technique (MCP/PMT). The MCP/PMT is expected to help combine the information from various KPIs identified in the first step. The MCP/PMT is the technique applicable at the functional and organizational levels. This technique attempts to identify an overall level of performance, given several ratios or measures. The MCP/PMT is based on the concept of the multi-attribute decisions, and involves with the use of the performance scale and the preference curve. See Sink and Tuttle (1989) for more details. Then, the third step involved the application of statistical analysis. This step was important for gaining more insights into the interrelationships between QWL and productivity. Finally, the findings with some recommendations would be shared with the new management team. See Figure 1.

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┌─────────────────────────────────────────────┐
│   Indentifying relevant QWL and productivity KPIs   │
└─────────────────────────────────────────────┘
                    │
                    ▼
┌─────────────────────────────────────────────┐
│   Applying the MCP/PMT for merging and        │
│   combining performance information           │
└─────────────────────────────────────────────┘
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                    ▼
┌─────────────────────────────────────────────┐
│   Applying statistical models for information and │
│   interrelationship analysis                  │
└─────────────────────────────────────────────┘
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                    ▼
┌─────────────────────────────────────────────┐
│   Sharing the findings and recommendations with the │
│   company's new management team               │
└─────────────────────────────────────────────┘
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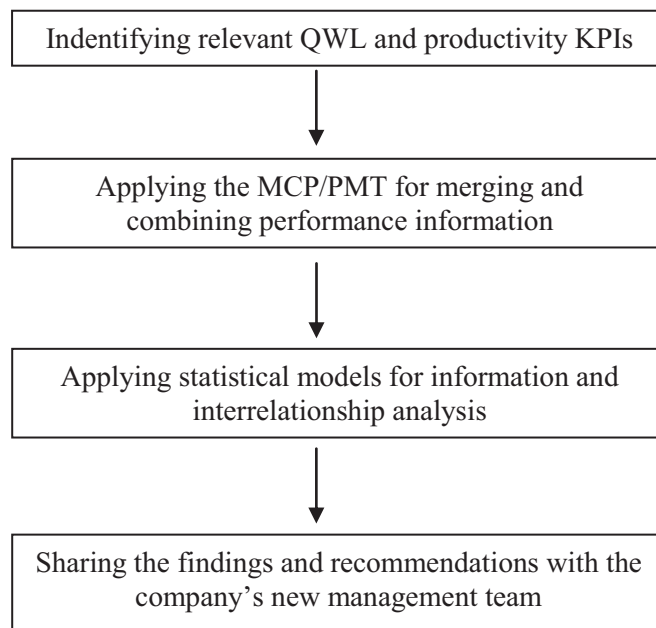
Figure 1: Study's Methodology

RESULTS

The measures that reflect QWL and productivity criterion were identified. The available data was gathered over the period during January 2010 to December 2010. Productivity was defined as the outputs (total products) over the inputs or resources consumed in the same

period for output generation (e.g., employee cost, contractor cost, capital cost, operating cost, and other costs). QWL dealt with how staffs feel about the workplace which includes pay, benefits, training opportunities, and workplace safety. input (e.g., employees and contracted workers' wage cost, employees and contracted workers' benefits, employees and contracted workers' training cost, number of accident cases, and number of injury cases) relatively to the number of employees and contracted workers. Table 1 illustrates the measures for Productivity (which consists of labor- and non-labor categories), QWLE (for employees) and QWLC (for contracted workers or contractors) to be analyzed on the monthly basis. From the welfare committee's viewpoint, productivity needed to focus the following two areas: (1) an overall level of productivity (i.e., labor and non-labor), and (2) labor productivity.

Table 1: Productivity, Labor, QWLE and QWLC Measures

Labor productivity	
Total Products (Barrel) ÷ Number of employees (Person)	PRODS ÷ NOE
Total Products (Barrel) ÷ Number of contracted workers or contractors (Person)	PRODS ÷ NOC
Total Products (Barrel) ÷ Employee costs (US$)	PRODS ÷ EC
Total Products (Barrel) ÷ Contractor costs (US$)	PRODS ÷ CC
Non-labor Productivity	
Total Products (Barrel) ÷ Capital cost (US$)	PRODS ÷ CaC
Total Products (Barrel) ÷ Operating cost (US$)	PRODS ÷ OC
Total Products (Barrel) ÷ Other cost (US$)	PRODS ÷ OtC
QWLE	
Employee wage (US$) ÷ Number of employees (Person)	EW ÷ NOE
Employee benefit (US$) ÷ Number of employee s(Person)	EB ÷ NOE
Employee training cost (US$) ÷ Number of employees (Person)	ET ÷ NOE
Number of employee incident cases ÷ Number of employees (Person)	EInc ÷ NOE
Number of employee injury cases ÷ Number of employees (Person)	EInj ÷ NOE
QWLC	
Contractor wage (US$) ÷ Number of employee (Person)	CW ÷ NOC
Contractor benefits (US$) ÷ Number of employees (Person)	CB ÷ NOC
Contractor training cost (US$) ÷ Number of employees (Person)	CTC ÷ NOC
Number of contractor incident cases (Time) ÷ Number of employees (Person)	CInc ÷ NOC
Number of contractor injury cases (Time) ÷ Number of employees (Person)	CInj ÷ NOC

Table 2 shows the some of the data used for this assessment study. Table 3 provides the demonstrations on how information from each measure was converted to the 0-100 performance scale. For this study, the performance scale of 0 to 100 is used for all measures (in reference to Table 1). For each measure, the value reflecting the best performance level (from January- December 2010) corresponded to the score of 100. On the other hand, the value reflecting the worst performance level corresponded to the score of 0. The average result over the study period (January- December 2010) corresponded to the score of 50. These three points (100, 50, and 0) formed the preference curve in which the remaining

results could be assigned and converted to the 0-100 performance scale. See Figure 2 for the preference curve for the Products-to-Operating Cost productivity measure.

Table 2: Demonstration of Some of the Data for Performance Measures

Period	Total Products (Crude Oil and Natural Gas converted to Barrels)	Employee Costs in $US	Contracted Workers Costs in $US	Operating Costs in $US
Jan. 2010	2,469,032.38	1,558,646	4,071,774	61,188,150
Feb. 2010	2,138,604.41	1,974,665	2,078,710	27,417,245
March 2010	2,538,788.46	1,400,859	4,141,780	57,561,301
April 2010	2,523,772.29	1,724,996	2,194,180	55,034,373
May 2010	2,310,491.98	1,898,387	2,813,014	44,471,228
June 2010	2,441,015.60	1,818,381	2,988,329	62,708,820
July 2010	2,528,201.01	2,012,820	1,823,546	78,865,356
August 2010	2,579,184.39	1,728,994	4,219,441	45,604,614
Sept. 2010	2,379,302.20	2,116,748	3,400,129	62,384,903
Oct. 2010	1,979,724.37	1,807,071	2,923,619	54,283,442
Nov. 2010	2,297,266.71	2,227,176	3,979,104	57,154,829
Dec. 2010	2,305,723.10	2,236,161	3,254,669	115,890,417

Table 3: Conversion from Performance Information to the 0-100 Performance Scale

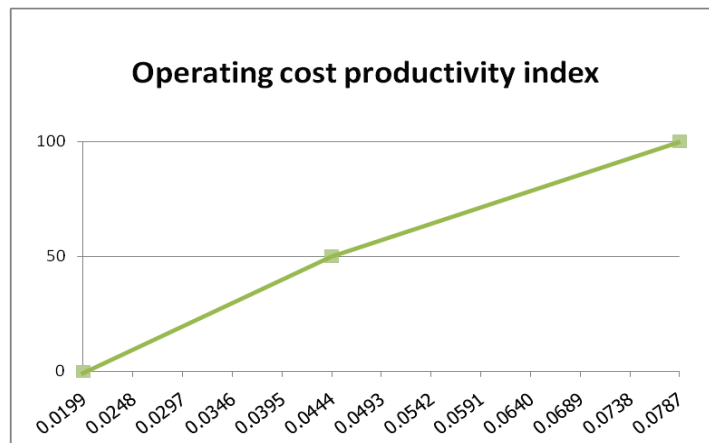| Period	Product ÷ Operating Cost Measure or Index	Score from the 0-100 Scale
Jan. 2010	0.0404	43.25
Feb. 201	0.0780 (*best performance*)	100.00
Mar. 2010	0.0441	51.19
Apr. 2010	0.0459	54.90
May 2010	0.0520	62.20
June 2010	0.0389	40.24
July 2010	0.0321	25.71
Aug. 2010	0.0566	68.88
Sept. 2010	0.0381	38.57
Oct. 2010	0.0365	35.05
Nov. 2010	0.0402	42.92
Dec. 2010	0.0199 (*worst performance*)	0.00
Average	0.0435	50.00

Figure 2: Preference Curve for Products-to-Operating Cost Productivity Measure

The next step involved the identification of an overall performance level from each of the four agreed areas; i.e., overall productivity, labor productivity, quality of work life for company employees, and quality of work life for contracted workers (designated as PROD, LABOR, QWLE, and QWLC respectively). The new management team agreed that all indicators would have the same weight. This decision was important once all individual indicators' performance information (within each of the four areas) was converted into the 0-100 scale. See Tables 4 and Appendix A for the overall performance levels.

Table 4: Weighted Average Scores for PROD (from Seven Labor and Non-labor Productivity Measures)

Month (2010)	Results from the 0-100 Scale							Weight	Overall Score (PROD)
	NOE	NOC	EC	CC	CaC	OC	OtC		
Jan.	73.12	72.79	77.97	6.29	100.00	43.25	71.14	1/7	63.51
Feb.	20.14	16.57	9.86	69.08	13.13	100.00	39.15	1/7	38.27
March	90.14	85.82	100.00	7.72	6.60	51.19	60.08	1/7	57.36
April	86.48	81.90	66.29	79.58	13.06	54.90	0.00	1/7	54.60
May	41.92	37.59	35.28	53.40	9.78	62.20	48.46	1/7	41.23
June	66.29	61.97	54.64	51.90	37.66	40.24	31.56	1/7	49.18
July	87.56	84.82	42.73	100.00	0.00	25.71	53.48	1/7	56.33
August	100.00	100.00	69.06	7.35	36.45	68.88	60.74	1/7	63.21
Sept.	51.23	66.47	17.65	26.53	51.47	38.57	37.40	1/7	41.33
Oct.	0.00	0.00	12.24	21.63	24.56	35.05	33.97	1/7	18.21
Nov.	31.21	44.35	0.07	0.00	32.71	42.92	100.00	1/7	35.89
Dec.	33.28	45.53	0.00	28.41	0.88	0.00	31.88	1/7	20.00

The next step was to test the following circumstances that were agreed by the new management team. Was the overall productivity level affected by labor productivity? Was the overall level of productivity is impacted by QWL from either employees or contracted

workers? Had the time-lag impacts played any role in influencing the overall productivity level? The approach used for statistical analysis follows Montgomery (1982) and Kutner *et al*., (2008). See Table 5.

Table 5: Variables for Statistical Analysis

Period	QWLE	QWLC	LABOR	PROD
1	49.98	66.28	57.55	63.51
2	70.19	36.23	28.91	38.27
3	41.78	50.19	70.92	57.36
4	55.27	47.32	78.56	54.60
5	65.32	44.57	42.05	41.23
6	59.04	42.46	58.70	49.18
7	54.00	50.11	78.78	56.33
8	72.62	58.28	69.10	63.21
9	73.35	38.85	40.47	41.33
10	61.97	50.91	8.47	18.21
11	74.54	86.75	18.91	35.89
12	85.42	47.55	26.80	20.00

For the question whether the overall productivity level was affected by labor productivity, according to the results from statistical analysis, labor productivity significantly affected the overall labor productivity level during January- December 2010. The increase in labor productivity improved the overall level of productivity.

Model Evaluation: Dependent variable: PROD
Independent variable: LABOR

	Sum of square	df	Mean square	F	p-value significance
Regression	1993.5	1	1993.5	34.94	0.000
Residual	570.5	10	57.0		
Total	2563.9	11			

	Un-standardized Coefficient		Standardized Coefficient	t	Sig.
	B	Std. Error	Beta		
Constant:17.929		5.061		3.54	0.005
LABOR: 0.559		0.0946	0.882	5.91	0.000

Regression Model 1: PROD = 17.929 + 0.559(LABOR)

This circumstance was tested, based on the following hypothesis (H_0: $\beta 1 = 0$, H_1: $\beta 1 \neq 0$). When the p-value is less than 0.05, then the null hypothesis is rejected at $\alpha = 0.05$, implying that this relationship was indeed significant. Additional statistical tests also showed that the

independent variables (LABOR) could predict the dependent variable (PROD) with the 77.8% confident level.

R	R Square	Adjusted R^2	Std. Error of the estimate
88.2	77.8	75.5	7.55289

For the question relating to the impacts from contracted workers on the overall level of productivity, the findings showed the following. The quality of work life from contracted workers affected the overall level of productivity concurrently with labor productivity and the increase of time (in months). In other words, if there was no significant improvement in QWLC and LABOR, the overall productivity level was expected to decline over time. The details are as follows.

Model Evaluation: Dependent variable: PROD
Independent variables: QWLC, LABOR, and TIME

	Sum of square	df	Mean square	F	Sig.
Regression	2329.88	3	776.63	26.55	0.0
Residual	234.05	8	29.26		
Total	2563.93	11			

Un-standardized Coefficient		Standardized Coefficient	t	Sig.
B	Std. Error	Beta		
Constant:13.62	8.594		1.58	0.152
QWLC:0.3278	0.1226	0.294	2.67	0.028
LABOR:0.48258	0.07827	0.761	6.17	0.000
TIME:-1.3708	0.5328	-0.324	-2.57	0.033

Regression Model 2: PROD = 13.62+0.3278(QWLC) + 0.48258(LABOR) - 1.3708(TIME)

R	R Square	Adjusted R^2	Std. Error of the estimate
95.3	90.9	87.4	5.409

Finally, the findings also reveaedl that the treatment of contracted workers could have negative impacts on the overall level of productivity. The reason was that QWLE significantly influenced the company's productivity. In addition, they had also known contracted workers quite well due to the nature of their work (as they stayed together at the sites). Company staffs realized that cost reduction that was applied to contracted workers would eventually put on them. In other words, there was the negative coefficient value from QWLE when considering the overall level of productivity. The details are as follows.

Model Evaluation: Dependent variable: PROD
                     Independent variable: QWLE

	Sum of square	df	Mean square	F	Sig.
Regression	943.5	1	943.5	5.82	0.036
Residual	1620.4	10	162.0		
Total	2563.9	11			

	Un-standardized Coefficient		Standardized Coefficient	t	Sig.
	B	Std. Error	Beta		
Constant:92.81		20.18		4.6	0.001
QWLE:-0.7526		0.3119	-0.607	-2.41	0.036

Regression Model 3: PROD = 92.81 - 0.7526(QWLE)

R	R Square	Adjusted R^2	Std. Error of the estimate
60.7	36.8	30.5	12.7297

The findings were shared and reviewed together with company's managing director, human resource manager, and contracted workers' union leader. Based on the first regression model, the overall level of productivity of the company is affected by labor productivity. The nature of work and tasks (i.e., off-shore exploration and drilling) which are classified as labor intensive indicate that labor productivity cannot be ignored. In addition, the hazardous characteristics and stressful working conditions cannot be overlooked as they negatively affected the labor productivity level.

Secondly, the overall level of productivity is impacted by contracted workers. According to the second regression model, as the QWL level for contracted workers increases, the company's productivity also improves. In addition, the results illustrate that, without an improvement in quality of work life for contracted workers and labor productivity, the overall level of productivity will decline over time.

Finally, the third regression model exposes that the issues relating to quality of work life are not confined with contracted workers. The company's employees' QWL positively affected the overall productivity level during January- December 2010.

CONCLUSION

 The study aims to provide the impacts and implications from a series of cost reduction decisions made by the previous management team for the company's new management team. Given the work stoppages, the study was proposed to evaluate the impacts from these

decisions and to examine the interrelationships between quality of work life and productivity. After having applied the MCP/PMT and statistical analyses, three important findings were revealed. The overall level of productivity of the company was affected by labor productivity. In addition, without an improvement in quality of work life for contracted workers and labor productivity, the overall level of productivity would decline over time. The overall level of productivity was positively influenced by company's employees. The significant implication for the new management team is that, instead of labor cost, the focus would be more on the operating cost. Finally, the study's limitations are recognized.

REFERENCES

1. Andersen, H., Lawrie, G., and Savic, N. (2004) "Effective quality management through third-generation balanced scorecard", *International Journal of Productivity and Performance Management*, Vol. 53, No. 7, pp. 634- 645

2. Arora, H. and Arora, P. (2013) "Measuring and decomposing productivity change using Hicks–Moorsteen index numbers: evidence from Indian banks", *International Journal of Productivity and Quality Management*, Vol. 11, No. 1, 73-95

3. Deming, W. (1986) "Out of Crisis" MIT Center for Advanced Engineering Study: MA, USA

4. Dobni, C. (2011) "The relationship between innovation orientation and organisational performance", *International Journal of Innovation and Learning*, Vol. 10, No. 3, pp. 226- 240

5. Dixon, J., Nanni, A., and Vollman, T. (1990) *The New Performance Challenge: Measuring Operations for World Class Competition*, Business One Irwin, Homewood, IL

6. Fasil, T. and Osada, H. (2011) "Multiple dimensions of TQM success in developing countries: an empirical study on Deming Prize winners from India and Thailand", *International Journal of Innovation and Learning*, Vol. 9, No. 2, pp. 184-203

7. Kathuria, R., Partovi, F., and Greenhaus J., (2010) "Leadership practices, competitive priorities, and manufacturing group performance", *International Journal of Operations & Production Management*, Vol. 30, No. 10, pp.1080 – 1105

8. Korunka, C., Hoonakker, P., and Carayon, P. (2008) "Quality of work life and turnover intention in information technology work", *Human Factors and Ergonomics in Manufacturing*, Vol. 18, No. 4, pp. 409-423

9. Kutner, M., Nachtsheim, C., and Neter, J. (2008) "Applied Linear Regression Models", John, Wiley & Sons: NY, USA

10. Montgomery, D. (1982) "Introduction to Linear Regression Analysis", John, Wiley & Sons: NY, USA

11. Reinhardt, W., Schmidt, B., Sloep, P., and Drachsler, H. (2011) 'Knowledge worker roles and actions – results of two empirical studies', *Knowledge and Process Management*, Vol. 18,No.3, pp. 150-174

12. Ropret, M., Fatur, P., Rodman, K., and Likar, B. (2012) "Factors of successful innovation in services and a performance comparison with manufacturing sector," *International Journal of Innovation and Learning*, Vol. 12, No. 4, pp. 379- 401

13. Sink, D. (1985) "Productivity Management: Planning, Measurement and Evaluation, Control and Improvement. John Wiley and Sons: NY, USA

14. Sink, D. and Tuttle, T. (1989) "Planning and Measurement in Your Organization of the Future" IE Press: Norcross, GA, USA

15. Steiner, G. (2008) "Supporting sustainable innovation through stakeholder management: a systems view", *International Journal of Innovation and Learning*, Vol. 5, No. 6, pp. 595- 616

16. Sumanth, D.J. (1985), "Productivity Engineering and Management", McGraw-Hill, New York, NY

17. Terziovski, M. (2006) "Quality management practices and their relationship with customer satisfaction and productivity improvement", *Management Research News*, Vol. 29 No. 7, pp. 414-424

Appendix A: Overall Scores for LABOR, QWLE, and QWLC

Table A.1: Weighted Average Scores for LABOR

Month (2010)	Results from the 0-100 Scale				Weight	Overall Score (LABOR)
	NOE	NOC	TEC	TCC		
Jan.	73.12	72.79	77.97	6.29	1/4	57.54
Feb.	20.14	16.57	9.86	69.08	1/4	28.91
March	90.14	85.82	100.00	7.72	1/4	70.92
April	86.48	81.90	66.29	79.58	1/4	78.56
May	41.92	37.59	35.28	53.40	1/4	42.05
June	66.29	61.97	54.64	51.90	1/4	58.70
July	87.56	84.82	42.73	100.00	1/4	78.78
August	100.00	100.00	69.06	7.35	1/4	69.10
Sept.	51.23	66.47	17.65	26.53	1/4	40.47
Oct.	0.00	0.00	12.24	21.63	1/4	8.47
Nov.	31.21	44.35	0.07	0.00	1/4	18.91
Dec.	33.28	45.53	0.00	28.41	1/4	26.80

Table A.2: Weighted Average Scores for QWLE

Month (2010)	Results from the 0-100 Scale					Weight	Overall Score (QWLE)
	EW	EB	ETC	EInc	EInj		
Jan.	6.68	20.76	22.44	100.00	100.00	1/5	49.98
Feb.	30.09	70.72	50.14	100.00	100.00	1/5	70.19
March	0.00	0.00	8.90	100.00	100.00	1/5	41.78
April	30.51	36.21	9.63	100.00	100.00	1/5	55.27
May	100.00	26.62	0.00	100.00	100.00	1/5	65.32
June	42.83	45.23	7.14	100.00	100.00	1/5	59.04
July	50.81	67.98	51.21	0.00	100.00	1/5	54.00
August	32.52	30.59	100.00	100.00	100.00	1/5	72.62
Sept.	78.92	68.62	19.23	100.00	100.00	1/5	73.35
Oct.	56.28	36.84	16.71	100.00	100.00	1/5	61.97
Nov.	43.80	100.00	28.91	100.00	100.00	1/5	74.54
Dec.	85.80	79.77	61.56	100.00	100.00	1/5	85.42

Table A.3: Weighted Average Scores for QWLC

Month (2010)	Results from the 0-100 Scale					Weight	Overall Score (QWLC)
	CW	CB	CTC	CInc	CInj		
Jan.	69.08	73.44	30.20	58.70	100.00	1/5	66.28
Feb.	26.09	8.36	15.14	31.55	100.00	1/5	36.23
March	90.90	59.37	0.00	0.68	100.00	1/5	50.19
April	14.41	16.82	46.32	59.03	100.00	1/5	47.32
May	26.70	46.53	17.31	32.31	100.00	1/5	44.57
June	0.00	67.23	13.03	32.06	100.00	1/5	42.46
July	2.24	0.00	68.88	79.46	100.00	1/5	50.11
August	32.01	100.00	59.39	0.00	100.00	1/5	58.28
Sept.	78.78	35.99	50.58	28.90	0.00	1/5	38.85
Oct.	12.14	61.21	23.29	57.91	100.00	1/5	50.91
Nov.	100.00	33.75	100.00	100.00	100.00	1/5	86.75
Dec.	24.94	60.67	93.74	57.91	0.49	1/5	47.55

ASSESSING PROCESS MANAGEMENT CAPABILITY: CASE STUDY OF DALLA SHIPYARD IN MYANMAR

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ABSTRACT

This study was conducted to assess and determine the level of process management capability (PMC) of Dalla shipyard and to evaluate the specific management processes to reengineer for improvement in PMC of the organization. This case study was conducted at Dalla Shipyard, Dalla Township, Yangon Region, Myanmar from October to December 2013. Of 7 operating processes and 6 management and support processes of the Process Classification Framework (PCF) derived from American Productivity and Quality Center (APQC), 6 management and support processes including human resources development and management (HRDM), information resources management (IRM), financial and physical resources management (FPRM),executing environmental management program (EEMP), improvement and change management (ICM) and external relationship management (ERM) were used to assess the level of PMC of case shipyard. Preliminary survey was carried out prior to case study and data was collected for case study by individual interview of 3 level groups such as management level group including 4 interviewees, supervisor level group including 6 interviewees and skilled worker level group including 6 interviewees. Comparing preliminary survey result and the result from case study, it was found that both results are same and HRDM, IRM, EEMP and ICM were the major common processes which are under poor management capability level of the organization while FPRM and ERM were at good level. Reengineering these processes with the improvement programs in specific weak areas might lead to the improvement of the whole PMC of the organization.

Keywords: Process management capability, Process Classification Framework (PCF), process management reengineering.

INTRODUCTION

All of the organization has to increase the efficiency and effectiveness of their business. They are confronted with the need to reduce costs by improving the performance of their business (Josef and Susanne, 2013). Business processes represent a key role in forming the optimal organization of modern enterprises (Ivana and Zeljana, 2012). Business processes can be described as series of logically related activities that use resources of the company. Its main goal is being satisfying customers' needs for products or services of adequate quality in an adequate period of time, while simultaneously achieving some value (Grover and et al., 1995).

Business process management (BPM) is a necessity to preserve a competitive market position (Josef and Susanne, 2013).BPM involves planning and administering the activities necessary to achieve a high level of performance in key business processes and identifying opportunities for improving quality and operational performance, and ultimately, customer satisfaction. Notably, It is not only applied in the private sector: It is a key concept in e-government and public sector reform (Becker, Algermissen, and Niehaves, 2006; Kubicek, Millard, and Westholm, 2003; Niehaves, Plattfaut, and Becker, 2012; Scholl, 2004; Scholl, Fidel, Liua, Paulsmeyer, and Unsworth, 2007; Stemberger and Jaklic, 2007; Weerakkody, Janssen, and Dwivedi, 2011). The importance on a management process has been recognized more in recent years (Kongkiti, 2010). Several models exist for assessing and guiding the development of BPM capabilities, a comprehensive picture of BPM capabilities in the public sector is however still missing in the extant literature (Bjoern et al., 2013).

Business process reengineering is the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical contemporary measures of performance such as cost, quality, service and speed. Business process reengineering mainly intervenes in the processing part, which is reengineered in order to become less time and money consuming (Hammer and Champy, 1993).

Even though other modes of transportation in Myanmar have been improved rapidly, Inland water transportation is playing an important and essential role of transport due to its natural navigable waterways of rivers in Myanmar. Therefore, Shipyards become profitable business for transportation in the country. Building and repairing of strength ships for transportation of heavy, bulky and large amount of cargoes are major processes in shipyards (IWT, 2013). Not only public sector but also private sector establishes shipyard business. Inland Water Transport (IWT), one of the state owned transport enterprises under the Ministry of Transport, was established since 1865. At present, IWT is a leading river transport enterprise providing a range of services for the secure and smooth transportation in Myanmar.

Until recently, public shipyards have to stand with government subsidy and have to operate for state business and some private customers. In the future, they may have to stand with their own budgets and have to seek markets and customers themselves. To compete market and meet customer's satisfaction, they need to understand and manage operational processes and management and support processes well. Without an effective management process, it is difficult for an organization to drive and fulfill its missions, policies and objectives.

PROBLEM STATEMENT

Since 2009-2010, Dalla shipyard has declined its performance capability and hasn't been able to reach its estimate goals and declination rate increases year by year (Table 2) (IWT, 2013). The weakness in performance skill of human labors, thereby increasing working hour and delaying performance process, may be the major problem of this declination.

Since 2010-2011, average cost for ship repairing of Dalla shipyard has increased progressively (Table 3) (IWT, 2013). The cost increasing problems may be weakness in material management increasing material waste and material cost due to the weakness in labor performance management and increasing labor cost due to the weakness in mechanization.

There are over 400 ships under Inland Water Transport (Table 4) (IWT, 2013). Of the ships under IWT, most of them have to repair every year due to poor ship building and repairing technical management and weakness in human labor performance management of Dalla shipyard.

OBJECTIVES

This study was carried out with the following objectives.
1. To assess and determine the level of PMC of Dalla shipyard.
2. To evaluate the specific management processes to reengineer for improvement in PMC of Dalla shipyard leading to its estimated goal.

LITERATURE REVIEW

Business process: Process is a structured, measured set of activities designed to produce a specified output for a particular customer or market (Hammer and Champy, 1993). Processes do not operate in isolation. They are linked together to form an overall management system(Peddle and Rosam, 2009).Major component of business process management are customer management, planning tend control, resource management, change process, learning and knowledge management, people and performance management(Antonie, 1998).Business

Process Reengineering (BPR) involves changes in structures and in processes within the business environment. The entire technological, human, and organizational dimensions may be changed in BPR(Zigiaris, 2000).

Process Classification Framework (PCF): APQC earlier developed the Process Classification Framework or the PCF to highlight the importance of process management and continuous performance improvement through benchmarking.The intent has been to create a high-level, generic enterprise model that will encourage businesses and other organizations to see their activities from a cross-industry process viewpoint instead of a narrow functional viewpoint. Many organizations now have used the PCF in practical ways to better understand their processes, to reach out across industry boundaries to communicate and share information, and to classify information in various forms. It supplies a generic view of business processes often found in multiple industries and sectors-manufacturing and service, healthcare, government, education, and others (APQC, 2013).

Dalla shipyard: As the state owned enterprise for transportation, the main objective of the IWT is to provide river transport services in Myanmar, utilizing its facilities to optimize transport performance while meeting public requirements.Shipyards of IWT include Dalla shipyard, Ahlone shipyard, Mandalay shipyard, Thanlwin shipyard, Sittwe shipyard, Chindwin shipyard. These shipyards are carrying out concerning major ship construction, ship repair and maintenance for inland water vessels(MOT, 2013).Nowadays, Dalla shipyard tries to upgrade ship Building Technology, Naval Architecture, Ship Repairing Technology, International Welding Engineer, Shipyard Management, Industrial Management, Sheet Metal Forming Technology, Marine Electrical and Electronic Engineer (IWT, 2013).

METHODOLOGY

Case selection: Dalla shipyard, Dalla Township, Yangon Region, Myanmar under IWT was selected as representative one among 10 public shipyards in Myanmar. This case study was conducted from October to December 2013. Of 7 operating processes and 6 management and support processes of the Process Classification Framework (PCF) derived from American Productivity and Quality Center (APQC), 6 management and support processes such as HRDM,IRM,FPRM,EEMP, ERM and ICM were used to assess the level of PMC of case shipyard.

Preliminary survey: First of all, strength and weakness of the major processes such as human resources development and management, information resource management, financial and physical resources management, executing environmental management program, external relation management and improvement and change management were questioned to the responsible admin official of the department. By this means, weak processes of the management fields in the department were generally evaluated.

Individual interview: Secondly, data were collected for case study by individual interview of 3 level groups such as management level group including 4interviewees, supervisor level group including 6 interviewees and skilled worker level group including 6 interviewees. Interviewing 16 persons from three different fields which could be all inclusive could get reliable and accurate answers as well. The scores 1 to 5 were defined as PMC levels where 1 means very poor level, 2 means poor level, 3 means intermediate level, 4 mean good level and 5 means very good level. If PMC level was very poor or poor or intermediate level, it was evaluated as poor level. If PMC level was good or very good level, it was evaluated as good level.

Data analysis: After having all data from individual interview, an analysis of variance (ANOVA) was performed using SPSS (version 16) software and lease significant different (LSD) was determined at 5%probability level to perform the comparison between the mean values.

Assessing PMC level of the organization: Finally, the results from preliminary survey and individual interview were compared to assess the major common processes which are under poor management capability level with the causes of the weakness.

RESULTS AND DISCUSSION

Preliminary survey: Figure 1 showed preliminary survey result on PMC of Dallashipyard. The organization can develop and manage human resource well; however, it was only 37.80%. 62.22% on that process was poorly managed by the organization. Therefore, it could be evaluated that the PMC of the organization on HRDM was at poor level. Although the organization can manage information resources, external relationship and improvement and change well, good management capability level on those processes were only 8.8%, 10% and 78.26% each and poor management capability level on those processes were 91.18%, 90% and 78.26% respectively.

Figure 1 Preliminary survey on process management capability (PMC) of Dalla shipyard

Individual interview: Table 1 presented PMC level of Dalla shipyard evaluated by three interwiewee groups. The output of the ANOVA analysis revealed that evaluations on PMC level of Dalla shipyard by three interviewee groups were not statistically different with the probability values of 0.06, 0.06, 0.62, 0.08, 0.49 and 0.57 (which are up 0.05) on HRDM, IRM, FPRM, EEMP, ERM and ICM respectively. Management level group evaluated the PMC level of the organization on HRDM was at intermediate level with the evaluation score of 2.46, which can be assumed as poor level. Supervisor level group and skilled worker level group concluded the PMC level of the organization on that process was at poor level with the scores of 2.27 and 2.36. Despite being well planned strategies, the organization cannot fully cast strategies to work level. Weakness in periodical training sessions based on the projects requirement leads to inadequate skilled manpower. Lack of recognition and reward on the performance of the employees makes poor job satisfaction for the employees. Provisions of hard head and hand protectors, eyes and ears protectors, safety shoes, safe working environment, adequate fire fitting appliances for the safety of employees are required by the organization. These might be the major causes of poor PMC level of the organization on HRDM. Three interviewee groups concluded the PMC level of the organization on IRM as poor level with the score of 2.32, 2.20 and 2.20 each. Our country is developing country and the organization cannot effort computer service and network operation system resulting weakness in information storage and retrieval, systems security and controls and information sharing and communication thereby poor PMC level of the organization on IRM. On the PMC level of the organization on FPRM, management level group and supervisor level groups defined as good level (3.58 and 3.47) while skilled worker level group, who are far from FPRM responsibility, did as intermediate level (3.41). For the PMC level of the organization on EEMP, all interviewee groups answered as poor level (1.80, 1.56 and 1.45 each). Not only public organization but also private ones in our country are not aware of the environmental issues relating with their businesses. The organization is also weak in planning environmental management strategy including training and educating employees,

implementing pollution prevention program, remediation efforts and emergency response programs. As the result on FPRM, management level group and supervisor level groups revealed as good level with the scores of 3.57 and 3.47 while skilled worker level group, who are far from ERM responsibility, did as intermediate level with the evaluation value 3.41 of the PMC of the organization on ERM. Three interviewee groups evaluated the PMC of the organization on ICM as intermediate level (2.65, 2.56 and 2.50), which can be assumed as poor level. Our shipyard is publically owned and all authorities on our organization are under Government control. Every decision comes from Government desire and wish. Therefore, Government support is important for all improvement and change programs.

CONCLUSION

Both preliminary survey result and the result from case study showed PMC on HRDM, IRM, EEMP and ICM of the organization were at poor level. Therefore, HRDM, IRM, EEMP and ICM were the major common processes which are under poor management capability level of the organization. Reengineering these processes with the improvement programs in specific weak areas might lead to the improvement of the whole PMC of the organization.

ACKNOWLEDGEMENTS

Table 1 Process management capability (PMC) level of Dalla shipyard evaluated by three interwiewee groups

Management processes	Calculated F value	Probability value	PMC level of Dalla shipyard evaluated by three interwiewee groups		
			Management level group	Supervisor level group	Skilled worker level group
Human resource development and management	3.59	0.06	2.46ab	2.27a	2.36b
Information resource management	3.49	0.06	2.32a	2.00b	2.00b
Financial and physical resource management	0.49	0.62	3.58a	3.47a	3.41a
Executing environmental management program	3.16	0.08	1.80a	1.56ab	1.45a
External relationship management	0.77	0.49	3.57a	3.47a	3.41a
Improvement and change management	0.58	0.57	2.65a	2.56a	2.50a

Values in column followed by the different letters are significantly different.

Figure 2 A: training room, B: working condition and C: information resource of Dalla shipyard

LITERATURE CITED

1. Antonie van, R. 1998.A framework for business process. **Computers ind.Engng**, 35(1-2): 217-220.
2. APQC (American Productivity and Quality Center), 2013. Available Source: apqcinfo@apqc.org and http://www.apqc.org
3. Becker, J., L. Algermissen and B. Niehaves. 2006. A procedure model for process oriented e-government projects. **Business Process Management Journal**, 12(1): 61-75.
4. Bjoern, N., P. Ralf and B. Joerg. 2013. Business process management capabilities in local governments: Amulti-method study. **Government Information Quarterly**, 30: 217-225.
5. Grover, V., S. R. Jeong, W. J. Kettinger, and J. T. C. Teng. 1995. The Implementation of Business Process Reengineering.**Journal of Management Information Systems**, 12(1): 109-114.
6. Hammer, M. and J. Champy. 1993. **Reengineering the Corporation: A manifesto for business revolution**, Harper Collins, London.
7. Ivana, M. and D. Zeljana.2012. **Implementation of the process approach and business process management concept in Croatian shipyards Management.** Knowledge Learning International Conference.
8. IWT (Inland Water Transport), 2013. Available Source: http://www.iwt.gov.mm/english/about_advantage.html
9. Josef, B. and L. Susanne. 2013. Success factors in process performance management.**Business Process Management Journal**. 19 (3): 477.
10. Kongkiti, P. 2010. **Process Management**. Department of Industrial Engineering, Faculty of Engineering, KasetsartUniversity,Thailand.
11. MOT (Ministry of Transport), 2013. Available Source: http://www.mot.gov.mm/mm/index.html
12. Peddle, R. and I. Rosam. 2009. **Process Management Auditing for ISO 9001:2008**. British Standards Institution, 2nd ed., UK.
13. Zigiaris, S. 2000. **INNOREGIO: Dissemination of innovation and knowledge management techniques**. MSc, BPR engineer, BPRHELLASSA.

SAFETY CULTURE MATURITY MODEL IN THAILAND BROAD INDUSTRY BORDIN VONGVITAYAPIROM

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ABSTRACT

Purpose: *The purpose of this paper is to identify safety culture maturity level of Thailand broad industry. It revealed 9 components/attributes of Thailand safety culture maturity in calculative level*

Design/methodology/approach: *This paper is a continuous research from Thailand baseline study in oil and gas industry using safety culture maturity of 5 levels (Hudson's model) to study in Thailand broad industry. A questionnaire survey was conducted to 200 respondents or 71% of target group and the results were used to find critical safety dimensions/attributes.*

Findings: *Results from questionnaire survey showed a safety culture maturity level of Thailand broad industry is at calculative, 9 identified components/attributes in 2 set of questionnaires are Safety management system priority and effectiveness, leadership and commitment, safety performance excellence, Safety identity, Safety sustainability, Employee priority, Manpower and line of sight, Risk taken and Management prompt response.*

Practical implications: *This paper provide a safety culture maturity snapshot for practitioners to compare and develop a plan to improve safety culture maturity in their organization*

Originality/value: *This paper provide 9 safety components/attributes for Thailand broad industry in calculative level in Thailand which will benefit Thailand government and organization on future policy making and improvement plan*

Keywords - Synergy, Research, Lessons learned, Safety culture maturity, Thailand

Paper type - Case study

INTRODUCTION

Researcher has studied safety culture in high risk industries e.g. oil and gas, nuclear and aviation since 1991, piper alpha disaster (IAEA, 1991). As consequence of incident in high risk industries has impact not limited to their employee and facilities but may also to the neighborhood, environmental contamination, multiple fatalities and disabilities. Once it occurs, company will suffer severe financial impact, major reputation damage, many litigation case and etc.

In the past few years, those catastrophes are "Macondo" accident in 2010, in the Gulf of Mexico for Oil and Gas industry which cause 11 men dies, 17 were injured and largest environmental oil spill in the history. In additional, year 2013 there was contaminated water with high levels of radiation leaked at Fukushima Nuclear plant to soil and sea water. One of the root causes of those catastrophes worldwide is poor safety culture and human error which quickly escalate the consequence of the accident.

Thai government has lesson learnt from those incident in 2013 which PTT, a national Oil and Gas company, has approximately 54,000 litres of oil leaked into the sea while discharging crude oil from vessel to refinery at 20 KMs south east of Map Ta Phut seaport. Oil spill has contaminated the sea water and the beach in one of the major tourist island. Since then ministry of labor has concern of safety culture in Thailand industry as trend of incident severity cost has increased since 2009 but recordable injury was vice versa. It means minor injuries were reduced but high severity incident remain (Ministry of Labor, 2012) and safety litigation case trend has also increased (Court of Justice, 2012).

Research team introduced Hudson's safety culture maturity model of 5 levels from pathological to generative (Hudson, 2007) to ministry of labor in 2011 and granted a permission to conducted a safety culture maturity baseline study in PTTEP, a subsidiary of PTT in oil and gas exploration and production industry. The model is recognized to be best practice in oil and gas industry and called "Heart and Mind program" using in Royal Dutch Shell Company.

Research team adapted Hudson's concept and tailored to PTTEP as in different country there is different culture and methodology (Schein, 2004) and found that the company is at calculative level. Short and long term roadmap has been implemented and the result significantly improved company's safety performance of lost time injury frequency (LTIF) by 45% in 2012 (PTTEP, 2013).

High safety culture maturity level is likely to have better safety performance, effective safety management system, prevent the incident and mitigate the consequence than lower level and being competitive among competitor especially in high risk industry which safety

Proceedings of 2014 International Conference on
Technology Innovation and Industrial Management
28th-30th May 2014, Seoul, South Korea

and environmental performance is one of the criteria to invest in foreign country (Board of Investment, 2012).

As catastrophes event in PTT arise in 2013 trigger Thai government to focus on safety culture maturity in broad industry to prevent for reoccurrence. This research is to identify safety culture maturity level of Thailand broad industry

Safety culture maturity intervention

Safety climate questionnaire (likert scale from 1-5) approach has been used since 1980 to understand safety culture in organization in various dimensions/elements and widely used in 2000. One of the reasons is safety climate questionnaire require short-mid term of participation e.g. distribute/collect survey and interview focus group. On the other hand, organization safety culture maturity level is harder to understand and require longer time for assessment e.g. survey scale is behaviorally anchored rating (likert scale from 1-5 with definition in each maturity level. The following are the example of safety culture maturity intervention in different country;

Filho (2010) used hearts and minds program for petrochemical companies in Brazil to measure their maturity level. 6 dimensions were selected for using in the questionnaire are information, organizational learning, involvement, communication and commitment. The intervention found each company maturity level is in proactive level and also noted that it is crucial to know where company stage is in to improve to next level. However, no further study on how to improve or step to the next level.

Gordon (2007) measured safety culture in an Air Traffic Management Research and Development Centre using SCMM method (Fleming, 2000) from level 1 emerging to level 5 continuous improvements. 4 dimensions were selected for using in the questionnaire which are management demonstration, planning and organizing, communication trust and responsibility, measuring auditing and reviewing. Implementation plan from questionnaire's result was focused on people issues. However, there is no further study on how to improve or step to next level.

Royal dutch/shell company developer of hearts and minds program, measure safety culture maturity itself and create short – long term plan which improve their safety performance till present in Oil and Gas industry.

Both Filho and Gordon interventions provide improvement plan based on the questionnaire result. However, there is no further study on how to improve to next level on each maturity level.

METHODOLOGY

The methodology of this research is described from questionnaire development, reliability examination, collection, analysis, comparison with baseline study and roadmap implementation as shown in following figure.
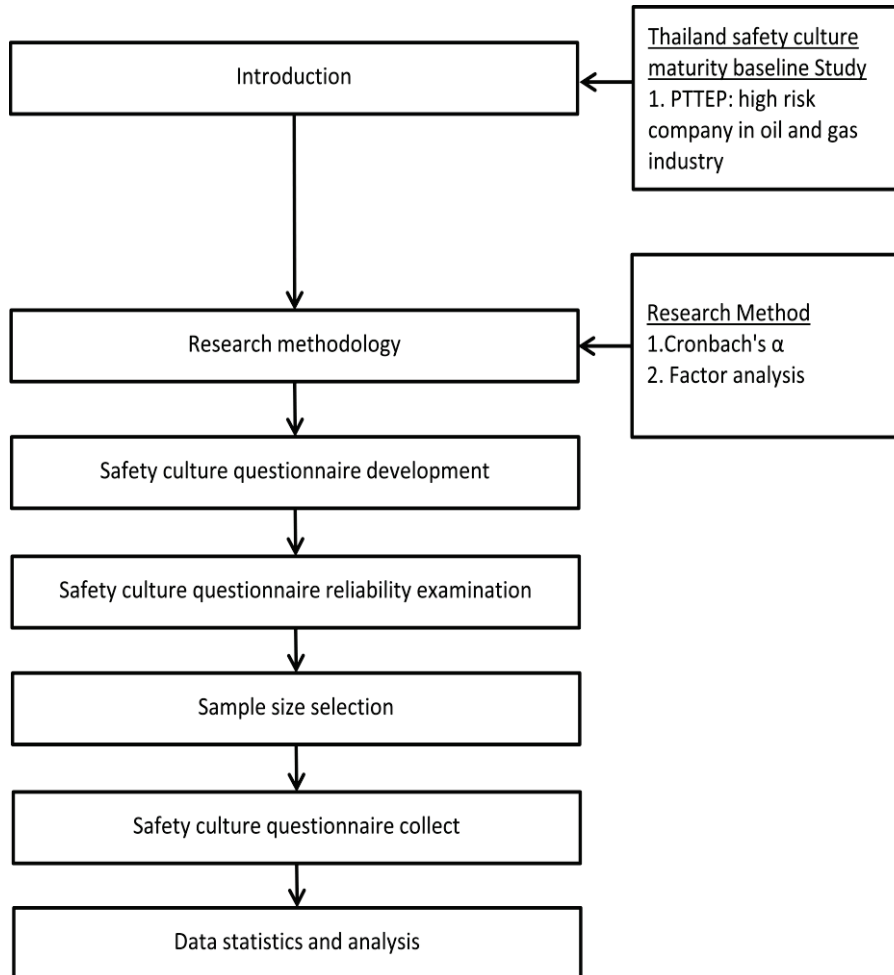

Figure 1. Research methodology for this paper

Questionnaire development

Safety culture survey is developed into 2 parts; the first part is to identify safety culture maturity in the basic assumption level (what are they really think) which comprised of 32 questions (likert scale with definition in each ranking from 1. pathological to 5. generative). The second part is to identify safety culture maturity in Artefacts/espoused value (what are they really act) which comprised of 41 questions (likert scale from strongly disagree 1 to strongly agree 5) (IAEA, 1991, Hudson & Willekes, 2000, Hudson, 2007, Guldenmund, 2010, International Association of Oil and Gas Producer [OGP], 2010, EU-OSHA, 2011). The questionnaire survey also collects respondents' gender, age, working experience, department and industry.

Questionnaire reliability examination

In order to validate the questionnaire, pilot test was conducted with safety expert, experience between 10 – 35 years in safety and related field, in different industry e.g., automobile, oil and gas, petrochemical and construction via online survey and follow up comment by in person and phone interview (n=15). Comments and recommendations were collected to adjust survey content to comply with safety in broad industry. Overall in safety expert point of view were positive and practical to identify safety culture maturity in Thailand broad industry. The reliability testing for the questionnaire with 73 items was conducted by using cronbanc's α coefficient with acceptable result >0.5 as shown in table.1.

Table.1. Mean, standard deviation, cronbach's α for reliability examination

Safety Culture Maturity Survey	Mean	Stdev	Cronbach's α	#Item
Part 1: Basic assumption	3.66	1.03	0.979	32
Part 2: Artefacts/espoused value	3.73	0.93	0.972	41

Both part 1 and 2 had acceptable reliability coefficients which could not be improved by removing any of the items.

Sample size selection

Research team selected the respondent from high, medium and low risk industry for instance, Oil and Gas, Automobile and Food & Beverage industry respectively to identify overall safety culture maturity in broad industry. Research team sent a request via Thai Ministry of labor to study safety culture maturity level in broad industry and submitted online survey on their behalf to selected risk ranking company in 2013.

Respondent Information

Researcher sent online survey to high, medium and low risk industry as resulting in 200 out of a total of 280 respondents. This measures out as 71% of the target group across Thailand industry. The respondent's information is shown in the following table;

Table.2. Respondent background in safety culture maturity survey

Information	% of Total	Overall
Q1. Gender		
Male	55%	3.78
Female	45%	3.59
Q2. Age		
<20	5%	3.63
21-25	43%	3.60
26-30	20%	3.69
31-35	10%	3.77
36-40	10%	3.77

Information	% of Total	Overall
41-45	4%	3.90
>51	8%	4.12
Q3. Service year		
<1	14%	3.72
1-4	39%	3.53
5-10	27%	3.69
10-15	3%	3.54
>15	18%	4.09
Q4. Position		
Operator/Worker	14%	3.59
Engineer/Officer	40%	3.66
Senior Engineer/Senior Officer	19%	3.68
Manager	20%	3.78
Vice President	2%	3.80
Senior Vice President and above	5%	4.02
Q5. Department		
Accounting	1%	3.70
Administrative	3%	3.24
Customer Service	3%	3.46
Marketing	3%	3.81
Operation	12%	3.75
Human Resources	3%	3.94
Sales	2%	3.63
Safety, Security, Health and Environment	30%	4.02
Finance	1%	4.34
Legal	1%	3.67
IT	1%	4.08
Engineering	13%	3.54
Product	1%	3.23
Research & Development	3%	3.34
Manufacturing	20%	3.21
Other	6%	3.48
Q.6 Industry	% of Total	Overall
Agriculture	2%	3.50
Architect & Construction	1%	3.60
Alternative Energy	1%	3.47
Aviation	4%	4.35
Banking	3%	3.38
Construction	9%	3.62
Consultant	1%	3.78
Education	2%	3.82
Energy	3%	3.45
Finance	2%	3.21

Information	% of Total	Overall
Government	3%	3.34
IT	2%	3.83
Logistics	4%	3.60
Manufacturing – Automotive	20%	3.93
Manufacturing – Chemical	3%	4.16
Manufacturing – Electronic	2%	3.63
Manufacturing – Food and Beverage	4%	3.33
Manufacturing – Paper	2%	4.20
Manufacturing – Steel	1%	3.74
Medical – Health care	1%	3.50
Non-profit organization	1%	3.34
Oil and Gas	22%	3.84
Petrochemical	10%	3.92
Sale and Marketing	1%	3.21
Telecommunication	1%	3.30

Correlation testing

The initial correlation matrix has been tested to find significance value which is greater than 0.05 to be non-appropriated and eliminated from analysis, result found all part 1 and 2 questions' significance level in the first and second part are lower than 0.05. Therefore all items proceed to next stage of data analysis.

Factor analysis suitability

Prior to extraction of the factors, Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy and Bartlett's Test of Sphericity should be tested to find whether data are suitable for using factor analysis techniques or not. The result of KMO and Bartlett's testing are the following table;

Table.3. Kaiser-Meyer-Olkin Measure of Sampling Adequacy and Bartlett's Test of Sphericity result

		Part 1: Basic Assumption	Part 2: Artefact/Espoused Value
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.967	.951
Barlett's Test of Sphericity	Approx. Chi-Square	6228.467	7402.639
	df	496	820
	Sig.	.000	.000

The KMO result for both part are > 0.5 and Barlett's Test of Sphericity significance level are 0.000 < 0.05 shown there are correlation among survey question. As result of the data are suitable to use factor analysis (Tabachnick and Fidell, 2012)

Selection of Rotation Method and low-loading item suppression

An aim of rotation is to maximize high item loadings and minimize low item loadings. Orthogonal Varimax rotation method is selected over Oblique rotation due to correlation among each factor could not be provided at current stage of the research. Therefore the assumption of factor uncorrelated has been made and Orthogonal Varimax rotation techniques is more suitable to use Moreover, it is the most common rotation technique used in factor analysis and literature (Thompson, 2004) with item loading below 0.4 were suppressed from rotated matrix output in order to get more reliable factor (Field, 2005; Lawrie, 2006)

RESULT

Safety culture maturity part 1: Basic assumption

Table.4. Mean, standard deviation of each safety culture questionnaire part 1: Basic assumption

Question	Mean	Stdev	Component 1.1	Component 1.2	Component 1.3
Q7. What is your company management attitude toward safety	4.24	0.98		.792	
Q8. How committed is management to making the company a more safer place to work	4.09	0.94	.402	.714	
Q9. How committed is workforce to making a company a safer place to work	3.72	1.03	.484	.644	
Q10. How involved is management in your company to safety activities	3.98	1.13		.720	
Q11. How involved is workforce in your company to safety activities	3.84	1.05		.712	
Q12. What are your management and workforce trust toward safety	3.75	1.00		.785	
Q13. How is management and supervisor perspective and support toward safety	3.62	0.94	.505	.609	
Q14. How is your company safety investment	3.71	1.29	.670	.419	
Q15. How is your organization set Occupational Health and Safety target/goal	3.72	1.43	.724		
Q16. How occupational health and safety target/goal reflect workforce contribution	3.46	1.26	.638		
Q17. How is your organization set reward and recognition for safety performance excellence	3.32	1.43			.785
Q18. What is safety management system role in your	3.23	1.41			.701

Question	Mean	Stdev	Component 1.1	Component 1.2	Component 1.3
organization e.g., ISO:18001, TIS:18001 and ILO					
Q19. How is your company safety personnel monitor and improve safety in operation	3.62	1.10	.664		
Q20. How is your company prepare for crisis and mitigate the consequence	3.70	1.09	.671	.449	
Q21. How are employees in organization understand their safety roles and responsibilities and manage line of sight	3.45	1.13	.552	.577	
Q22. How safety is being considered in procurement process in your company	3.56	1.29	.751		
Q23. How safety is being considered in each project life cycle in your company	3.76	1.13	.608		
Q24. How is your company use safety tools and techniques to analyze and prevent hazard in operation	3.88	1.07	.524	.491	.428
Q25. How safety statistics is being recorded and reported in your organization	3.79	1.25	.715		
Q26. Do your organization benchmark safety performance with same/other industry	3.48	1.31	.605		.517
Q27. How safety communication is being conducted to all stakeholder in your company	3.72	1.25	.823		
Q28. How is your company provide safety standard, guideline and procedures to support each operation and activity	3.37	1.09	.742		
Q29. How is your company manage contractor safety performance and safety management system	3.51	0.99	.583	.448	
Q30. How is your organization assist contractor to improve safety performance	3.67	1.09	.607	.430	
Q31. How is your organization informally communicate safety information	3.78	1.27	.763		
Q32. How is your organization put importance on safety	3.54	1.13	.655		.433

Question	Mean	Stdev	Component 1.1	Component 1.2	Component 1.3
compliance and regulatory					
Q33. How is your company provide safety training to improve employee safety competency	3.56	1.25	.592		*.467*
Q34. What is your attitude toward safety audit and review	3.70	1.15	.552		*.530*
Q35. How is your company respond to audit finding	3.68	1.04	.532	*.495*	
Q36. What is your company manage safety information, database and data transparency	3.55	1.06	*.412*	*.506*	.537
Q37. How is your organization invest in CSR activity	3.81	1.18	.564	*.404*	
Q38. How employees in your company attitude toward safety culture/climate survey and what to be done next	3.43	1.25	.745		

*Cross-loading items are in *italics*

Component 1.1: Safety Management System priority and effectiveness

In the first component comprise with 21 items and 5 cross-loading items. Each item relate to safety management system and its' priority with different focus area. 6 items are focus in safety performance management areas which are target setting, how to benchmarking with peer, documentation, how to record and improve both employee and contractor safety performance and safety management. 13 items aim to generate effective safety management system e.g., to put safety in each project life cycle, proper safety resources to support operation, priority setting in audit and review/compliance and regulatory/training and competency and improvement based on each project life cycle activities.

The rest are involved with safety communication to all stakeholders in the organization both formally and informally. Therefore, in this component identify the safety culture maturity in basic assumption level with the result of each items are relate with tangible outcome for instance, target setting and policy, budget allocation in safety category, audit tracking close out items and backlogs. Based on the review of the item content, this component is called **"Safety Management System Priority and Effectiveness"**.

Component 1.2: Leadership and Commitment

Component 1.2 comprise with 8 items with 8 cross-loading items with all relate with leadership and commitment of top management which can be shown directly by relationship between supervisor and subordinate, how the safety problem being taken care of in each roles and responsibilities, participation in safety activities and top management being a role model in safety which will become trust among employee in organization. Based on the content review, this component is called **"Leadership and Commitment"**.

Component 1.3: Safety Performance Excellence

Component 1.3 comprise with 3 items and 5 cross-loading items. Loading items are about how to management safety information, data transparency in organization which each individual and department has their role and responsibilities in safety management system which indirectly impact safety performance of organization (Flin, 2000) and will determine whether organization will give reward and recognition for safety excellence or not. Those may base on organization's nature of industry (high/medium/low risk), profit and management point of view on safety. Based on the content review, this component is called **"Safety Performance Excellence"** which is the outcome and contribution of every aspect in organization.

Summary part 1: Safety culture maturity level in Basic Assumption level

Table.5. Summary Principle Component Analysis and scale statistics for part.1- basic assumption

Component number and label	Number of Item	Eigenvalue	Variance explained (by component)%	Cronbach's α
1.1 Safety Management System Priority and Effectiveness	21	10.72	33.52	0.975
1.2 Leadership and Commitment	8	7.21	22.53	0.936
1.3 Safety Performance Excellence	3	4.40	13.75	0.800

In summary, safety culture maturity part 1: Basic Assumption has 32 questions in likert scale from 1 pathological to 5 generative with each questionnaire answer definitions and descriptions. It aims to identify safety culture in the deepest consciousness in each employee by mapping their safety behavior and mindset in their daily routine with questionnaire answer. Total 200 respondents from various industry completed the survey with the result of overall safety culture maturity level in part 1 is at 3.66 or Calculative level. Data analysis using principle component analysis which extract factor into 3 components as "Safety Management System Priority and Effectiveness", "Leadership and Commitment", "Safety Performance Excellence" with variance explained 33.52%, 22.53% and 13.75% respectively.

Safety culture maturity part 2: Artefacts/Espoused value

Table.6. Mean, standard deviation of each safety culture questionnaire part 2: Artefacts/Espoused value

Question	Mean	Stdev	Component					
			2.1	2.2	2.3	2.4	2.5	2.6
Q39. Management of my company are always concerned about health and safety of employees	4.00	0.90	0.77					
Q40. Management of my company are concern occupational, health, safety and environment as core business equal to quality and productivity	3.77	0.88	0.75					
Q41. Management of my company are always lead and carry out safety action outside meeting room	3.83	0.95	0.74					
Q42. Management of my company are always support occupational health, safety and environment campaign and activities	3.78	0.82	0.79					
Q43. Management of my company are always be a role model	3.62	0.85	0.75					
Q44. Supervisor of my department place a high priority on fixing safety problem identified by employees	3.77	0.87	0.63		0.49			
Q45. Supervisor always check and monitor if employee follow safety rule	3.94	0.93	0.73					
Q46. Supervisor in my department are always praise subordinate for working safely	3.81	0.85	0.65					
Q47. My company always invest to improve safety in company	3.80	0.87	0.60	0.45				
Q48. Employee have trust in safety management system, supervisor and among worker to work safely	3.88	0.99	0.54		0.48			
Q49. Employee feel improvement on safety performance are part of their contribution of safe operation	3.93	0.90		0.53	0.56			
Q50. My company has set a challenge HSE target	3.79	0.91	0.46	0.66				
Q51. My company has set a reward and recognition for working safely	3.64	0.95		0.76				
Q52. Implementation of safety management system are important in my	3.80	0.86		0.68				

Question	Mean	Stdev	Component					
			2.1	2.2	2.3	2.4	2.5	2.6
Q53. In my company, there is enough safety officer to support daily operation	3.74	0.85		*0.48*		*0.63*		
Q54. In my department, there is enough safety officer to support daily operation	3.78	0.82				*0.68*		
Q55. Accident investigation in my company are always effective to identify the root cause of the incident	3.77	0.73	0.53		*0.40*			
Q56. In my company, there are continuous safety improvement from incident, near miss and report from employee to improve safety performance and eliminate hazard in operation	3.61	0.92	0.57		*0.41*			
Q57. In my company, employee are always follow standard and procedure	3.61	0.87	0.49			*0.46*		
Q58. In my company, employee understand what to do during emergency and crisis	3.80	0.86	*0.56*			*0.56*		
Q59. In my company, employee understand their roles and responsibility in safety and manage line of sight effectively	3.94	0.89	0.55			*0.50*		
Q60. In my company, HSE is always concerned in procurement process	3.11	1.09		0.68				
Q61. In my company, HSE is always concerned in each project's life cycle	2.99	1.12		0.68				
Q62. In my company, employee always report on injury and near miss incident	3.83	0.85		0.49	*0.48*			
Q63. In my company, HSE statistics is always recorded and reported to management	3.60	0.92	*0.41*	0.72				
Q64. In my company, safety is sometimes compromised for the sake of production and other	3.93	0.97					0.85	
Q65. In my company, employee is regularly take risk to achieve their target	3.78	0.78					0.88	
Q66. Management are quick to give feedback on what action have been taken when employee reported safety problem	3.75	0.92		*0.43*				0.56
Q67. In my company, HSE statistics is always benchmark with peer company	3.30	0.87	0.65					

Question	Mean	Stdev	Component					
			2.1	2.2	2.3	2.4	2.5	2.6
Q68. There are always safety communication in my company	3.87	0.86	0.59	0.47				
Q69. Employee and contractor always has enough resource to perform work safely	3.85	0.88	*0.44*		*0.59*			
Q70. Employee and contractor are always stop work when it is unsafe	3.73	0.87			0.54			
Q71. In my company, there are safety problems that have not been solved for long time	3.90	0.82					0.67	
Q72. My company provide necessary training for employee	3.71	0.91	0.59					
Q73. My company see audit as a way to improve safe work/condition	3.79	0.84	0.54	*0.44*		*0.45*		
Q74. In my company, audit finding are always completed within timeframe	4.00	0.90			0.66			
Q75. New staffs in my company always get safety induction, training and supervised by senior staffs	3.77	0.88	0.45	0.43	0.58			
Q76. In my company, employee are always conduct job safety analysis before work	3.83	0.95	0.61		*0.43*			
Q77. In my company, employee are encourage to talk and suggest about safety	3.78	0.82	0.66					
Q78. In my company, there are always invest on CSR activities	3.62	0.85		0.59				
Q79. In my company, they regularly conduct safety culture/climate survey to improve safety culture in organization	3.77	0.87	0.61					

*Cross-loading items are in *italics*

Component 2.1: Safety Identity

First component of safety culture maturity survey part 2 comprise of 20 items which 11 items relate with Top management leadership, commitment and support e.g., being a role model in safety, safety is one of the top priority in company and safety budget allocation. 3 items relate with front line supervisor to check and monitor their daily operation and 6 items are relate with employee's roles and responsibilities, trust and how they act in their normal routine. Component 2.1 reflects overall nature of organization which explains into how employees do, act and think of safety in their daily operation.

Those come from company's direction which issued and led by their management and cascade to front line supervisor to supervise employee to act according to the plan with management training, tools and technique. Base on content review, this component is called "**Safety Identity**" which explain each organization has unique perspective toward safety which maybe vary based on industry, profit, history, management and legislation.

Component 2.2: Safety Sustainability

Component 2.2's contents are relate with safety statistics and outcome, priority in safety management system, impact to society, and employee with 4, 3, 1, 1 items respectively. It aims to highlight organization safety performance along with priority in all process and care to society by conducting corporate social responsibility. It can also be said that organization with good safety performance in their industry with concern to neighbor and social can benefit to company among competitor especially high risk industry in international level. Base on content review, this component is called **"Safety Sustainability"** which describes organization to maintain good safety performance through safety statistics which benchmarking with peer in the same and different industry to gain advantage among their competitor both in domestic and international level.

Component 2.3: Employee Priority

Component 2.3 comprise with 5 items with 4 of them relate to employee and their support and 1 is relate to audit and review. It show concern to employee to work in daily operation safely with proper support from company for example, orientation for new employee for safety rules and regulation in worksite, proper personal protective equipment for each worker's work and reflect their good record of safety performance by performance appraisal. Company should provide support to employee by providing standard, guideline and procedures, policy and other in safety management system for employee to follow and even stop work when there are abnormal situation as said in component 2.1 safety identities. Base on content review, this component is called **"Employee's Priority"**

Component 2.4: Manpower and Line of Sight

Component 2.4 comprise with 3 items relate to safety resources (personnel) to support daily operation in department/company level and roles and responsibility during crisis (crisis management). Those bear in mind, this component have strong correlation to safety

manpower (personnel) and their roles and responsibility according to each position in company. When all are being reviewed, this component is called **"Manpower and Line of Sight"**.

It mean in each organization should have enough safety personnel to run their normal operation without taking unnecessary risk and comply to country's legislation e.g., Thailand's regulation require an organization to have safety officer in company with specific proportion to all employee in organization in manufacturing sector with understanding in their safety roles to support company dynamic environment.

Component 2.5: Risk Taken

Component 2.5s' contents are different than other component that describe positive attitude and indicate items that positive and good safety culture maturity should have but vice versa. It comprise with 3 items relate with employee is taking risk in order to achieve their target and goal, safety is being compromised to other and problem has not been solved for a long time. Those items should be eliminated to provide employee with confident to work to their fullest without aware to uncertain working environment. Based on the content review, this component is called **"Risk Taken"**.

Component 2.6: Management Prompt Response

There is only 1 item loading on this component which describe the action taken which suggest by management to cascade down to all stakeholders in order to mitigate the exposure risk being identified by employee. Those can be found in various ways based on management style and safety management system for instance, it can be found in safety observation card which employee can fill up the form and send to their supervisor or the safety issues has been raised in their monthly safety management committee and management suggest what should be done and by whom. Therefore, based on those contents review, this item is called **"Management Prompt Response"**

Summary part 2: Safety culture maturity level in Artefacts/Espoused values

Table.7. Summary Principle Component Analysis and scale statistics for part.2-Artefacts/Espoused value

Component number and label	# Item	Eigenvalue	Variance explained (by component)%	Cronbach's α
2.1 Safety Identity	20	10.41	25.40	0.972
2.2 Safety Sustainability	9	7.35	17.93	0.927
2.3 Employee Priority	5	4.48	10.94	0.852
2.4 Manpower and Line of Sight	3	3.40	8.29	0.793
2.5 Risk Taken	3	2.10	5.13	0.733
2.6 Management Prompt Response	1	1.20	2.93	N/A

Safety culture maturity survey part2: Artefacts/Espoused value comprise of 41 questions in likert scale from 1 strongly disagree (Pathological) to 5 strongly agree (Generative). The survey aims to identify safety culture in surface to middle level of respondent consciousness by using straight forward question relate to their normal daily operation and interactive among employee, supervisor and management level. Total 200 respondents from various industry completed the survey with overall safety culture maturity level in part 2 is at 3.73 or Calculative level. The analysis has been made using principle component analysis which extract factors into 6 components as "Safety Identity", "Safety Priority", "Employee Priority", "Manpower and Line of Management", "Risk Taken" and "Management Prompt Response" which all component focus on different area in Thailand broad safety culture. Those are explained in total variance of 70.61% separate from component 1 to 6 as 25.40%, 17.93%, 10.93%, 8.29%, 5.13% and 2.93% respectively.

CONCLUSION

Overall score in part 1 (3.66) are lower than part 2 (3.73) show the current working environment and employee perception that what they think they were actually not the thing there are. Except leadership and commitment that strongly presented but in employee point of view, they still are not enough. Survey result show safety culture maturity of Thailand broad industry is at calculative level for both basic assumption and artefacts level. 3 and 6 extracted factor for part 1 and 2 can be used to develop a campaign or roadmap to improve the maturity level from calculative to proactive and generative in the future.

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Technology Innovation and Industrial Management
28th-30th May 2014, Seoul, South Korea

FUTURE RESEARCH

The commonalities in extracted factor can be used to find, validate and confirm critical factors for organization to achieve safety culture maturity in calculative level in Thailand broad industry. Hudson's safety culture maturity model should be test in pilot organization to find safety culture maturity level and compare the result with Thailand broad industry. Research team should also focus on developing roadmap to improve safety culture maturity level from calculative to proactive and generative level as it will benefit Thai government in future policy making and industry to be competitive in Asian Economic Community (AEC) in 2015.

REFERENCE

1. Board of Investment, Thailand (BOI) (2012), "The Report Thailand 2012", Bangkok: Ministry of Industry, pp. 99-122.
2. Court of Justice, Thailand (2012)," Annual report 2012", Bangkok: Ministry of Justice, pp.15-78.
3. EU-OSHA (2011), *Occupational Safety and Health culture assessment – A Review of Main Approaches and Select Tool*, European Agency for Safety and Health at Work.
4. Field, A. (2005), "Exploratory factor analysis", in Field, A. (Ed), *Discovering Statistics using SPSS*, Sage, London, UK, pp. 627-686.
5. Filho, A. P. G., Andrade, J. C. S. and Marinho, M. M. O. (2010), "A Safety Culture Maturity Model for Petrochemical Companies in Brazil", *Safety Science,* Vol. 48, No. 5, pp. 615-624.
6. Flin, R., Mearns, K., O'Connor, P. and Bryden, R. (2000), "Measuring Safety Climate: Identifying the Common Features", *Safety Science.* Vol. 34, No.3, pp. 177-192.
7. Gordon, R., Kirwan, B. and Perrin, E. (2007), "Measuring safety culture in a research and development centre: A comparison of tow methods in the Air Traffic Management domain", *Safety Science.* Vol. 45, pp. 669-695.
8. Grote, G. and Kunzler, C. (2000), "Diagnosis of Safety Culture in Safety Management Audits". *Safety Science,* Vol. 34, pp. 131-150.
9. Guldenmund, F. W. (2010), "(Mis)understanding Safety Culture and Its Relationship to Safety Management", *Risk Analysis,* Vol.30, pp. 1466-1480.
10. Hudson, P. and Willekes, F. C. (2000), "The Hearts and Minds Project in an Operating Company: developing tools to measure cultural factors", in *Health, Safety, and the Environment in Oil and Gas Exploration and Production Proceeding of the SPE International Conference* in Texas, United State of America.
11. Hudson, P. (2007), "Implementing a Safety Culture in a Major Multi-National", *Safety Science,* Vol. 45, No.6, pp. 697-722.
12. International Atomic Energy Agency (IAEA) (1991), "Safety Culture", Vienna: International Atomic Energy Agency.

13. International Association of Oil and Gas Producers (OGP) (2010*),* "A guide to selecting appropriate tools to improve HSE Culture report no.435", London: International Association of Oil and Gas Producers, pp. 1-18.

14. Lawrie, M., Parker, D. and Hudson, P. (2006), "Investigating Employee Perceptions of a Framework of Safety Culture Maturity", *Safety Science,* Vol. 44, No. 3, pp. 259-276.

15. Ministry of Labor, Thailand (2012), "Annual report 2012", Bangkok: Ministry of Labor, pp. 43-156.

16. Petroleum Authority of Thailand in Exploration and Production, Thailand (PTTEP) (2013), "Annual report 2013", Bangkok: Ministry of Energy, pp.1-150.

17. Schein, E. H. (2004), "Organizational Culture and Leadership", *Jossey-Bass*, San Francisco, pp. 1-437.

18. Tabachnick, B. G. and Fidell, L. S. (2012),"Cleaning up your act, Screening data prior to analysis", in Tabachnick, B. G. and Findell, L, S (Eds), *Using Multivariate Statistics,* Pearson Education Inc, Boston, USA, pp.60 – 116

19. Thompson, B. (2004), "Exploratory Factor Analysis Decision Sequence", in Thompson, B. (Ed), *Exploratory and Confirmatory Factor Analysis: Understanding Concepts and Applications,* Washington DC, USA, pp. 27-48

OPERATION RISK MANAGEMENT OF PLANNING AND PIPING DESIGN IN A LARGE PETROCHEMICAL PLANT PROJECT

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ABSTRACT

This study was carried out at a well-established company which is a leader in design engineering, machinery and equipment procurement, and construction (EPC). The company has substantial experience of more than 30 years in the field of petrochemical plants based on turnkey projects. The company has handled more than 200 projects in Thailand and overseas. The plant includes production line, utility systems, storage, conveyance and transportation of products. Capacity of project investment cost is limited at USD500 million. The target customers are classified in 3 areas: petroleum plants, petrochemical plants and chemical plants.

The piping problems were identified during fiscal years 2011 to 2013 during which time numerous projects were unable to be completed according to the requirements of the customers. The problems were mainly caused by internal processes. The problems focused sharply on piping design which is not directly related to actual site work. Many faults in piping design forced the company to reorder and rework. From the track record of problems during the period of this study, the project cost for reorder material increased dramatically compared to original offer costs. Internal processes such as waiting for piping design between internal departments also delayed the overall process. Under current organization, each department is independently managed, leading to poor cooperation between departments. These issues led to poor quality of work and project delays cause of overall lack of efficiency. Customer satisfaction and trust were damaged, threatening the company's chances of winning further projects. At the end of fiscal year 2013, on-going projects were

valued at 32,200 million Thai baht. Meanwhile, backlogged projects were valued at 6,740 million Thai baht.

This research reduced project losses by using failure mode and effect analysis (FMEA) as a tool for analysis of the piping design department. The samples were selected from five projects. It was found that nine majors points yielded a risk priority number (RPN) higher than 125. Results of RPN calculation concerning four topics revealed that the RPN value was reduced from 211 to 75, demonstrating a 64.4 percent improvement.

Keywords: failure mode and effect analysis, piping design and drawing process, control plan

INTRODUCTION

Loss of investment is a primary concern for any company. On the topic of loss reduction, Ploycharoenpanich (1998) found several tools and techniques that are applied to prevent investment loss. The most important tool to minimize losses is to employ a QC circle to identify problems through brainstorming. Seven QC tools (Korpornkalng, 2002) are generally applied to problems which are analyzed using statistical methods. The collected data is then used to make decisions and rectify problems appropriately by employing statistical tools such as data collection through checklist. The data is then plugged into a Pareto diagram from which a team will arrange the problems according to their level of severity. The issues are all put in a "Fish Bone Diagram" (Rittipakdee, 2011). These quality tools are used in many processes such as loss control and reduction in the metal sheet forming industry (Setanun, 1999).

Several local industries have applied Failure Mode and Effect Analysis (FMEA) (Phuabhisit, 2000). FMEA was initially applied in auto parts manufacturing (Thongpraiwan *et al*., 2010). It is also widely used in cable manufacturing (Sribunchan *et al*., 2007) and electronics manufacturing (Pasuk *et al*., 2009). The results from FMEA are classified into two groups. The first group is used for analysis by design teams to evaluate failure trends which could occur in the future. It also reviews mechanisms which could lead to failure. The second group is used to understand the relative risk of each activity in a process. The second group links these activities together to determine failure trends. It also performs analysis to control and reduce risks.

Similar research concerning equivalent procedures began with analyzing the level of severity of problems, then conducting analysis with a Fish Bone Diagram, followed by analysis of failures and effects with FMEA. Finally, all of the analysis data is input to a control plan. Jiwawongsawas et. al. (2007) applied FMEA and analytic hierarchy process (AHP) for process improvement at a ceramic coating industry facing major quality problems with some of its products. Prada et. al. (2007) did analysis using FMEA for the production of fire protection coats for all processes and calculated the Risk Priority Number (RPN) using a

Pareto Diagram. The control plan in that study revealed that productivity increased up to 15.32 percent and waste in process decreased by 11.15 percent. Rittipakdee (2011) studied methods to improve the painting process for the automobile industry. He used cause and effect diagrams to determine production problems plus created a relationship diagram and Tree Diagram to determine the major problems. Starmatics (2003) applied FMEA to categorize risk evaluation as follows: slight risk (RPN<60), moderate risk (RPN<80), high risk (RPN<100) and crisis risk (RPN>100).

Review of the related literature has enabled the researcher to apply FMEA theory in genuine planning and piping design. It is for analysis and identifies failures which could occur. FMEA is also employed for making a sample control plan. Scipioni (2002) studied the ways in which FMEA can control and reduce waste from design processes which effect quality in the petrochemical industry.

RESEARCH METHODOLOGY

A research method consisting of seven processes is shown in Figure 1. It begins with a study of design and collection of data of the piping design and drawing process, followed by analysis of the data to determine failures. By using a cause and effect diagram, analysis is performed using FMEA. The findings are then arranged according to RPN using a Pareto chart. Processes with high RPNs are then selected for rework. Finally, the data is applied with a control plan and the results are summarized.

Figure 1 Research Methodology

Studying design and drawing process

The process of design and drawing comprises a variety of steps. It begins with project data as shown in Figure 2. The FMEA technique does not account for technical specifications, design and drawing. After the design and drawing are complete, the isometric process, plus the piping and instrument diagram (P&ID) are matched with the vendor's drawings together with information from other departments. Then, the data is rechecked and calculated. If the data is not correct, the process will go into a loop until it passes the qualifications before it is handed over to the construction department.

Piping Arrangement (GA) and Isometric Drawing (ISO)		
P&ID (Process Flow Diagram)		
Piping Arrangement		
Pipe Support	ISO Drawing	Final Material

Piping information
1. Section 2d drawing from 3d for piping arrangement
2. Piping stress analysis sheets
3. Pipe support detail and data

1. Extract ISO drawing from software

1. Extract MTO file
2. Create MTO report from software

ISO drawing Extraction
1. Remodel and complete final annotation in ISO drawing

Material take off (MTO)
1. Check commodity code And MTO file before loading to MARIAN
2. MTO final lot

3d Piping modeling
1. Reload final data to data base
2. Model pipe support details
3. Incorporate review comments
4. MTO second lot

Piping Department

Piping Department

Piping department

90% model review
Confirm all small bore piping and file supports
1. Piping above ground (A/G) < 2" piping, pipe support

ISO Drawing

MARIAN
(Integrated life cycle material and supply chain management)

GA Drawing

Project Management (PM) Tool

Figure 2 Design and drawing process

Fault data from design and drawing
Design and drawing before improvement

This research collected data between 2011 and 2013. It was found that the percentage of losses over the project value tended to increase continuously as demonstrated in Table 1 and Figure 3. Faults were classified into four types of problems. Each group includes internal details with a description of the type of loss as shown in Table 1.

Table 1 Unplanned costs due to design and drawing faults from 2011 to 2013

Year	Project Value (Million Thai Baht)	Re-Order Cost (A) in Million Thai Baht	Cost of project correction (B) in Million Thai Baht	Total Cost (A+B) in Million Thai Baht	Percentage of Loss (A+B/P, %)
2011	15,010	6.2	1.6	7.8	0.05
2012	16,499	14.4	2.6	17	0.10
2013	32,200	30.8	10	40.8	0.13
				Average	0.09

Figure 3 Unplanned costs due to design and drawing faults

Cause and effect of faults and waste analysis using fish bone diagram

From the design and drawing process through the project handover to the end customer comprises 8 internal processes. Group brain storming among several departments was conducted to analyze the effects of faults. The quality tool used for this analysis is a cause and effect diagram as shown in Figure 3.

Figure 3 Cause and effect diagram

Failure analysis using FMEA technique

Failure analysis is very important to determine cause and effects in the manufacturing process. It is used to solve problems systematically. It helps prevent losses before they occur. FMEA technique also enhances systematic problem solving skills. It is used by a project team to rearrange processes and prevent the high probability of loss on projects. FMEA consists of the methods explained below.

Pipe layout, material selection, pipe loading design and risk analysis are considered for selection and design. Brainstorming raising issues for design properties. Requirements for internal work and design must consider maximum usage, design must meet customer requirements and design must aim for maximum safety. From brain storming to analysis trending of failure due to piping design, nine types of failures were categorized. Failures were mainly caused by poor design which did not comply with the customer's specifications. Some designs contributed to poor efficiency. Some designs failed due to material selection. Moreover, some design work caused parts damage during actual use. Table 2 summarizes the processes that led to failures.

Potential failure mode is a normal specification in the sub-processes. If a sub-process does not comply with original specifications, "what will each department do to resolve the failure?" Potential failure mode is shown in Table 2.

Failure detection methods in the current situation employ 3D simulation. These methods are used to determine failure and test the most suitable design. The design is then transferred to CAESAR II program (Pipe stress analysis) for design and calculation of mechanical support.

Process control during the current situation is employed to control possible failures. Table 3 shows guidelines for fault control. This data is used for calculating in FMEA by arranging the risk priority number (RPN). RPN refers to results that will cause harm to the project. A higher RPN relates to a higher degree of risk. The calculation of RPN is shown in equation 2.1 as follows:

$$RPN = S \times O \times D$$

Where
S is Severity
O is Occurrence
D is Detection

Constraint: S, O and D are integers ranging from 1-10

Risk Priority Number Calculation (RPN)
Results from RPN calculation reveal that the highest RPN value is 280 points and the lowest value is 32 points as shown in Table 4. Table 4 shows the RPN value for the piping layout process.

Table 2 Summary of failure trends and cause of failure due to piping design

Piping Design Properties	Requirement	Potential Effect Mode	Potential Effect of Failure	Potential Cause Of Failure
1. Piping Layout	1) 1A. Piping lay out is fit on specified area	1A-S1 Pipe lay out is too close, not according to drawing	1A-S1-E1 Pipe crushed, causing damage.	1A-S1-C1 No standard of piping alignment
	2) 1B. Tie in pipe with designed equipment	1B-S1 Tie in with nozzle which not according to P&ID	1B-S1-E1 Damage in Equipment	1B-S1-C1 Failure from designer
	3) 1C. Pipe alignment for ease of use	1C-S1 Customer must have suitable access to pipes	1C-S1-E1 Inconvenient work space	1C-S1-C1 In proper design of valve location
	4) 1D. Need flow efficiency	1D-S1 Low flow	1D-S1-E1Reduction in machine efficiency	1D-S1-C1 Design by using pocket is made drip leg.

Table 2 Summary of failure trends and cause of failure from piping design (Continued)

Piping Design Properties	Requirement	Potential Effect Mode	Potential Effect of Failure	Potential Cause Of Failure
2. Material design	1) 2A. Material must conform to design specification	2A-S1 Wrong material specifications	2A-S1-E1 Corrosion occurred during operation	2A-S1-C1 Incorrect input to design program
3. Load design	2) 3A. Support must be able to take load from pipe	3A-S1 Bending support	3A-S1-E1 Collapsed pipe	3A-S1-C1 Wrong calculation especially at joint connector
4. Operate Risk analysis	3) 4A. Proper sizing for pipe support	4A-S1 Under-sized pipe support	4A-S1-E1 Bending support, collapsed pipe	4A-S1-C1 Incorrect input parameter in pipe design program
	4) 4B. Pipe appearance must not crack or bend during operation	4B-S1 Cracked pipe	4B-S1-E1 Damage in pipe	4B-S1-C1 Wrong material
	5) 4C. Nozzle joint must not be damaged	4C-S1 Nozzle damage	4C-S1-E1 Chemical leakage	4C-S1-C1 Inappropriate support for pipe

Table 3 Summary of control process under current conditions

Piping design specification	Potential Cause	Failure control	
		Prevention	detection
1. Piping lay out	1A-S1-C1 No standard piping lay out	Drawing review	3D simulation program
	1B-S1-C1 Designer fault		
	1C-S1-C1 Inappropriate design for valve installation position		
	1D-S1-C1 Using pocket made drip leg		-
2. Material selection	2A-S1-C1 Wrong input for material specification		-
3. Loading design	3A-S1-C1 Under-sized for load design		Use CAESAR II for calculation
4. Operation risk analysis	4A-S1-C1 Wrong data input for application		
	4B-S1-C1 Improper material selection		
	4C-S1-C1 Mis-matched pipe support		

Process selection for analyzed control plan with Pareto diagram

When RPN numbers are rearranged using a Pareto diagram, the data is distributed and grouped to reveal the stability of data by frequency distribution count. Important data will have a low number or a vital few. In contrast, less important data will yield a high number or many trivial points. From data analysis, it was found that the major processes can be classified in nine crucial processes as demonstrated in Table 4.

Table 4 Failure analysis

Item	Requirement	Potential Effect Mode	Potential Effect of Failure	SEV	CLASS	Potential Cause Of Failure	OCCUR	Current Design Control		DETECT	RPN	Recommended Action (s)	Responsibility & Target Date	Action Results				
								Prevention	Detection					Action Taken	SEV	OCC	DET	RPN
1.Pipe Layout	Do pipe layout based on design drawing	Tight pipe lay out does not conform to drawing	Hard to access	7		No standard of pipe lay out	6	Review drawing before handing to customers	Simulation using 3D Program	4	168	Preparation for Standard of Pipe Installation	Piping Dept Month/YY	Preparation for standard of pipe alignment	5	3	4	60
	Installation of pipe to machine of equipment	Wrong connection of pipe to nozzle, does not conform to drawing	Damage on Equipment	8		Fault from designer	2	Review drawing before construction	Simulation using 3D Program	4	64							
	Pipe layout based on ease of access	Customers have suitable access to equipment	Customers cannot use equipment easily	7		Design and installation for valve at high position	7	Review drawing before handing to customers	Simulation using 3D Program	4	196	Preparation for standard of valve installation	Piping Dept Month/YY	Preparation for standard of valve installation	5	4	4	80
	Flow Efficiency	Liquid moves with high friction	Machine cannot work at design efficiency	8		Using pocket in design drip leg	3	Review drawing before handing to customers	-	2	48							

Table 4 Failure analysis (Continued)

Item	Requirement	Potential Effect Mode	Potential Effect of Failure	SEV	CLASS	Potential Cause Of Failure	OCCUR	Current Design Control		DETECT	RPN	Recommended Action (s)	Responsibility & Target Date	Action Taken	Action Results			
								Prevention	Detection						SEV	OCC	DET	RPN
2.Material Selection	Material specification must conform to design specification	Wrong material selection	Corrosion during operation	8		Wrong input during programming	7	Review before handing to customers	-	5	280	Prepare standard check list	Piping Dept Month/YY	Preparation of check sheet	5	5	4	100
3.Pipe loading design	Pipe support must be able to resist pipe down force	Bending pipe support	Pipe collapse	8		Under-sized load calculation	2	Review drawing before handing to customers	Use CEASAR II program for load simulation	2	32							
4.Operation risk analysis	Pipe clamp and support must be proper for use	Pipe support too small	Pipe support deflection	8		Wrong input for pipe support	5	Review drawing before handing to customers	Use CEASAR II program for load simulation	5	200	Prepare standard check list	Piping Dept Month/YY	Preparation of check sheet	5	3	4	60

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28th-30th May 2014, Seoul, South Korea

Table 4 Failure analysis (Continued)

Item	Requirement	Potential Effect Mode	Potential Effect of Failure	S E V	C L A S S	Potential Cause Of Failure	O C C U R	Current Design Control Prevention	Detection	D E T E C T	R P N	Recommended Action (s)	Responsibility & Target Date	Action Taken	S E v	O C C	D E T	R P N
	Pipe must have no defects during operation	Defect and cracks of pipe	Plant/Factory down	8		Pipe material not applicable	2	Review before handing to customers	Use CEASAR II program for load simulation	3	48							
	Joint and nozzle must have no damage	Damage on nozzle	Chemical leakage	7		Pipe support cannot hold the pipe	3	Review before handing to customers	Use CEASAR II program for load simulation	3	63							

Results from RPN arrangement

RPNs were arranged from low to high as shown in Figure 4. In this study, RPNs higher than 125 points were selected for improvement. Four of the nine problems were selected for improvement. The important issues comprised pipe layout in two problems, material selection in one problem and risk of use in one problem.

Figure 4 Risk priority number for each issue raised

Results and discussion to resolve failure

Topics with RPN higher than 125 points are summarized in Table 5.

Table 5 Cause and effect to resolve topics with RPN higher than 125 points

Piping design properties	Trend of problem	RPN
1. Pipe layout	1A-S1-C1 No layout standard	168
	1C-S1-C1 Inappropriate design for valve installation position	196
2. Material selection	2A-S1-C1 Wrong input during programming	280
4. Operate risk analysis	4A-S1-C1 Wrong data input for pipe application	200

Based on Table 5, the action team discussed the problems and solved them by referencing other project databases. The problems were solved as demonstrated in Table 6.

Table 6 Summary of problem solving for piping design

Properties	Trend of Failure	Cause	Solution	Pictures before solving	Pictures after solving
1. Pipe layout	1A-S1 Pipe laying too close together	1A-S1-C1 No standard of alignment	Prepare standard of alignment		
	1C-S1 Customer must reach very high to operate the valve	1C-S1-C1 Improper valve location	Prepare standard installation		
2. Material selection	2A-S1 Material selection is not correct according to customer specifications	2A-S1-C1 Wrong input for material specification	Prepare material check list		
4. Operate risk analysis	4A-S1 Improper pipe support size	4A-S1-C1 Wrong input for pipe application	Prepare standard check list		

Rearrangement and Evaluation of revised RPN

After reviewing the processes with RPNs, the piping designers revised the standard of design. The quality control team then recalculated the RPNs. New RPNs were less than 125 points for each of the four failures evaluated in this study, representing an improvement of 64.4 percent. Therefore, new piping design methods will be applied to confirm the results again. Table 7 shows the RPN before and after improvement.

Table 7 RPN before and after improvement

Properties	Trend of Failure or Mechanism	Solution	RPN		
			Before Improve-ment	After Improve-ment	Percentage Improvement
1. Pipe layout	1A-S1-C1 No standard of alignment	Prepare standard of alignment	168	60	64.3%
	1C-S1-C1 Improper valve location	Prepare standard installation	196	80	59.1%
2. Material selection	2A-S1-C1 Wrong input for material specification	Prepare material check list	280	100	64.3%
3. Operate risk analysis	4A-S1-C1 Wrong input for pipe application	Prepare standard check list	200	60	70%
		Average	211	75	64.4%

From RPN point re-calculation of four major types of failure, it was found that RPN points were reduced from 211 to 75 after improvement, representing a 64.4 percent reduction in RPN.

Figure 5 RPN before and after process improvement

RESEARCH CONCLUSIONS

This research has established steps risk assessment for the piping design process from a sample company. The company is mature in the petrochemical and chemical plant building business. Design failure mode and effect analysis has been applied to evaluate and determine risks from process failures. Solutions were designed to protect piping systems before failures occur. Nine crucial topics of failure were evaluated in this research. Each topic yielded a risk priority number (RPN) higher than 125 points. A summary of how to prevent failures or problems is shown in Table 8.

Table 8 Summary of solutions for failure prevention of piping design

Trend of Failure or Mechanism	Solution
1A-S1-C1 No standard of alignment	Prepare a standard of installation based on customer specifications
1C-S1-C1 Improper valve location	Prepare a standard of piping design and installation at proper position for ease of access
2A-S1-C1 Wrong input for material specification	Prepare standard checklist of material before actual construction
4A-S1-C1 Wrong input for pipe application	Prepare standard checklist for support to match actual site work and construction

Failure Mode and Effect Analysis (FMEA) of late project transfer to customers significantly reduced problems. During the study of FMEA of five ongoing projects, nine crucial failure topics were identified. Four topics had RPN higher than 125. A committee then researched ways to determine solutions to the problems. The RPNs were reduced from an average score of 211 points to 75 points, representing or 64.4 percent reduction of problems.

REFERENCES

1. Jirawongsawad K, et al., 2007. Applying **FMEA and AHP for Process Production Improvement**; Case Study Ceramic Industries. Industrial Engineering Network Seminar (Thailand), 24-25 October.

2. Korpornkalng S. 2002. **Quality Control**, 2nd Publication Bangkok: Sky Books Printing Co., Ltd.

3. Pasuk, W., et. al. (2009), **Waste Reduction for Chromium Plating by Using Six Sigma Case Study from Chromium Plating Industries**, Industrial Engineering Network Conference Thailand, 24-25 October.

4. Phuabhisit P, 2000. Waste **Reduction from Cutting Process in Metal Forming Industries**, Industrial Engineering, Chulalongkorn University.

5. Ploycharoenpanich K, 1998.**QC Circle at site work**, 1st publication. S. Asia Press Limited.

6. Prada, A. and N. Kuptadsathien. 2007. Failure Mode Analysis and Effect in Anti Fire Suite **Production and Control Plan for Increasing Productivity**: Case Study Anti Fire Suite Industries, Industrial Engineering Network (Thailand).

7. Rittipakdee, A. 2011. Quality **Improvement for Painting Process in Auto Mobile Industries**., Industrial Engineering, Chulalongkorn University

8. Scipioni, A. 2002, FMEA methodology design, **Implementation and integration with HACCP system in a food company**. Food Control, Volume 13.

9. Setanun, W, 1999. **Waste Parts Reduction in Auto Parts Production**, Industrial Engineering, Chulalongkorn University

10. Sribunchan, P. and S. Lapnonkwar. 2007. **Waste Reduction in Hard Disk 1Production by Using Six Sigma**, Industrial Engineering Network Seminar (Thailand), 24-25 October.

11. Stamatis, D.H. 2003. Failure Mode and Effect Analysis: **FMEA from Theory to Execution**, 2nd ed. Milwaukee, Wisconsin: ASQ Quality Press.

12. Thongpraiwan, W and N. Kuptadsathien. 2010. **Applying FMEA for Glass Moulding Design and Development Improvement**, Industrial Operation and Development Symposium, Thammasart University. 7th May 2010.

ORGANIZATIONAL LEARNING, HUMAN CAPITAL, HUMAN RESOURCE PRACTICEA AND INNOVATIVE CAPABILITY IN R&D PROFESSIONALS OF SMEs IN TAIWAN

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ABSTRACT

The purpose of this research is to discuss the relationship between organizational learning capability, human capital, human resource practices in R & D professionals and innovative capability. Data were collected from 161small and medium-sized Taiwanese firms by questionnaire. Results showed that organizational learning capability positively affects human capital and human resource practices in R&D professionals. Moreover, human capital and human resource practices in R&D professionals are significantly and positively related to the innovative capability of an organization, but organizational learning capability does not significantly affect organizational innovative capability. Organizational learning capability will positively affect innovative capability of an organization through the mediating of human capital and human resource practices in R&D professionals. Enterprises should strengthen their organizational learning capabilities and moreover, increase their innovative capabilities by preserving human capital and conducting appropriate human resource practices in R&D professionals.

Keywords：Organizational Learning Capability, Human Capital, Human Resource Practices, Innovative Capability

INTRODUCTION

In the knowledge economy era, developing R&D innovative capability is not only a key element for competitiveness but a basic capability for small and middle-sized enterprises (SMEs) seeking sustainable operations. SMEs play an important role in economic growth, since they can bring into play entrepreneurship and innovativeness, complement large businesses, increase the quality of human capital, and stabilize the foundations of society.

Taiwan's vigorous and innovative SMEs have been a key factor in the economic development in Taiwan. However, SMEs in Taiwan now face problems such as shortages of labor, high wage costs, land prices, and market saturation, in addition to severe competition from developing countries. Hence, the most important issue in industrial structure transformation for Taiwanese

SMEs pursuing sustainability is how to strengthen the innovative capability to move away from the historical strategies of strategies of OEM, copying, and modification.

Innovative product development is a competitive strategy for enterprises in fast changing industrial conditions, and R&D is the key factor for innovative product development. Enterprise leaders should actively conduct technological innovation to extend product life cycle and create industrial competitiveness (Lu and Lazonik, 2001). Currently, for most enterprises in Taiwan, R&D operations have became the most important segment among enterprise operations, with many companies increasing market share and gaining extra profit by developing innovative technologies and products. Additionally, they have created competitive advantages that competitors cannot match. Therefore, R&D capability and innovative capability are key factors in international market competitiveness for Taiwanese enterprises.

Lacking natural resources and facing increased labor costs, SMEs in Taiwan should switch from depending on wage cost competition to cultivating valuable and unique human capital. Since human capital is easily copied by competitors, for an organization, the higher the human resource quality in high value added jobs, the higher the profit created. Further, unique human capital higher makes greater contribution to competitive advantage and core capability for an organization (Stewart, 1997). Currently, Taiwan is facing hi-tech human resource shortages. Hence, the key factor in hi-tech human resource development is whether Taiwan is able to maintain sufficient human resources, especially R&D personnel. Stata (1989) proposed that in a fast changing environment, organizational learning capability has became the only source for an enterprise to maintain core competitive advantage. Bartlett and Ghoshal (2000) argued that an enterprise must build its competitive advantage through its human resources. Thus, creating competitive advantage through human capital is the most important issue in human resource management. Nahapiet and Ghoshal（1998）argued that organizational innovativeness is closely related to human capital and organizational learning. Because organizational innovativeness involves the creation of new knowledge, or a novel recombination of existing knowledge, it is closely related to human capital and organizational learning.

Given the foregoing, this study explores whether organizational learning capability within an enterprise can increase its innovative capability, and whether it can increase its human capital and human resource management（HRM） activities in R & D professionals, in order to enhance its innovative capability of an enterprise. Given that the internal process of building an organizational learning climate is the key for Taiwanese SMEs to retain their competitive edge, in this study, we will establish a better understanding of innovative capability through investigation a firm's organizational learning capability, human capital and HRM activities in R & D professionals. In the final part of this study, the results are presented, along with a discussion of the implications for organizations.

Organizational learning and Human capital Organizational learning is a process which converts individual knowledge enhancement and understandings into organizational activity improvement (Fiol and Lyles, 1985). Although organizational learning has its roots in individual learning (Senge, 1990), almost all organizational learning related research has emphasized that organizational learning is different from individual learning, though they are closely related. The key point of such learning is how to convert, spread, and store knowledge from individual learning in the organization (Grant, 1996). Jerez-Gómes, Céspedes-Lorente, and Valle-Cabrera (2005) argue that organizational learning is the capability of an organization to process knowledge: in other words, to create, acquire, transfer, and integrate knowledge, and then modify organizational behavior to reflect - 3 - the new cognitive situation, with a view to improving performance.

In recent years, many scholars have explained the organizational learning process from the viewpoint of knowledge. For example, Huber (1991) proposed that organizational learning can be classified into knowledge acquirement, knowledge spread, information interpretation and organizational memory. Nevis, DiBella, and Gould (1995) integrated organizational learning processes into three steps: knowledge acquirement, knowledge sharing, and knowledge exercise. Sinkula, Baker, and Noordewier (1997) measured organizational learning using three aspects of the organization: commitment to learning, shared vision, and open-mindedness toward the organization.

Dixon (1994) argued that a learning organization spontaneously performs organizational conversion continuously through adaptive learning and innovational learning. Nonaka and Takeuchi（1995）argued that human capital alone may not benefit the organization if there are no mechanisms in place for employees to share knowledge with one another. Consequently, a successful learning organization needs a continuous learning culture, and needs to provide an environment that facilitates learning to accelerate learning among all organizational members, in order to constantly enhance the human capital of an organization. Probst, Raub, and Romhardt (2000) also pointed out that human capital should increase leverage effects by encouraging employees to learn constantly, or to participate in all decision-making processes to enhance knowledge skills and commitment to learning in the organization. Buren (1999) proposed that human capital is a kind of intellectual capital. Buren's organizational intellectual capital management model can be divided into three major activities: first, finding out how much intellectual capital remains in an organization; next, through the knowledge management process (define, initiate, acquire, sharing, exercise) and leadership (building a common organizational vision), advance organizational culture, organizational structure, technology and procedure; and last, pushing ahead with organizational achievement and enhancing intellectual capital stock.

Hsu（2007）found that a learning organization expects employees to use company time to pursue knowledge outside the immediate scope of their work, hence increasing human capital. If an organization does not encourage the development of knowledge, employees will not be motivated to pursue learning activities（Calantone et al., 2002）. For this reason, through organizational learning, enterprise employees can enhance their capability and equip themselves and the organization with high added value knowledge, increasing human capital.

Thus, we hypothesize:

H 1：The level of organizational learning capability is positively related to human capital.

Organizational learning and HR practices in R & D professionals Ulrich(1997) proposed that when capital and production technologies became easier to acquire, the source of competitive advantage tends tends to be the cultivation of the internal capabilities of the organization, especially strategic management of human resources (Dyer, 1984； Wright and McMahan, 1992 ； Lado and Wilson, 1994；Pfeffer, 1994). Smith (2004) proposed that the existence of organizational learning culture also includes encouraging - 4 -learning by the organization itself and individuals within groups. Thus organizational learning culture is an important factor in enabling human resource development to achieve strategic valued results. Pedler (1997) proposed that a learning organization must encourage and support learning activities in the organizational culture, to create a learning atmosphere in the organization; and through strong human resource management activity, integrate all the learning efforts of the enterprise, setting up strategic targets and continuously developing and making breakthroughs. Wayne, Shore, and Liden (1997) proposed, if the individual plays a key role in the organizational learning process, then human resource management plays a fundamental role in organizational learning. Given the foregoing, we hypothesize:

H2：The level of organizational learning capability is positively related to HR practices in R & D professionals.

Organizational learning and Innovation Capability.

Organizational learning is considered a part of the organizational change process. It not only changes organizational knowledge, belief and behavior, but can enhance the drivers of organizational growth and innovation (Watkins and Marsick, 1993). Hurley and Hult (1998) proposed that when an organizational culture is learning-oriented, it will act as a guide to innovative culture, and organizational innovative culture will affect organizational innovative capability. Further, they argued that the characteristics of organizational culture, such as

participation in decision-making, authority sharing, support and collaboration, and learning and developing, will affect the innovation behavior of organization members, and will enhance organizational innovative capability.

Calantone et al. (2002) proposed organizational learning tends to elevate innovative capability; first, an organization can produce breakthrough technology; moreover, organizational learning can grasp market movements; finally, an organization can comprehend advantages and disadvantages of competitors through learning, and moreover elevates innovative capability of itself. Cohen and Levinthal (1990) indicated through learning, an enterprise can absorb and assimilate the environment outside and it will help with innovation activity within the enterprise. Argyris and Schon（1978）proposed that under the same organizational conditions, organizational learning can enhance the innovation capabilities of an organization in the future.

Stata (1989) found that organizational learning can cause innovation.

In knowledge-intensive industries, innovations due to individual and organizational learning are the only source of enduring competitive advantage for an organization. Liao, Fei, and Liu (2008）found that higher organizational learning ability will lead to better performance in administrative and technical innovation.

Given the foregoing, this research proposes that in order to elevate the innovative capability of an enterprise, organizations must increase organizational learning. We thus hypothesize:

H3：The level of organizational learning capability is positively related to organizational innovative capability.

Human capital, HR practices in R & D professionals, and innovation capability - 5 -Human capital is a combination of technology storage and individual knowledge within an organization. It can also include the values and culture of an enterprise, as well as its philosophy (Lynn, 2000; Edvinsson and Malone, 1997). It is a competitive advantage for an organization to have highly motivated employees equipped with unique characteristics, as human capital is the most unique and most valued intangible asset (Edvinsson and Malone, 1997), it also is the source of organizational innovation and reform (Stewart, 1997). As a result, an enterprise abundant in human capital may find it easier to advance process reformulation or carry out value added innovation. An enterprise that possesses skilled and knowledgeable employees will have higher human capital and be able to generate knowledge, perform correct decision-making, and thus stimulate better organizational innovation (Hitt, Bierman, Shimizu, and Kochhar, 2001). Guthrie (2001) pointed out that rich human capital of an enterprise brings both innovative ideas for the

firm, and improved organizational procedures. Moreover, customer problems can be promptly solved. Therefore, an enterprise should reinforce the development of employee capabilities to make them better able to contribute to the organization. For that reason, we argue that if an organization possesses highly capable employees, it can utilize organizational resources to produce organizational innovative capability. We thus hypothesize:

H4 : The level of human capital is positively related to organizational innovative capability.

Since human resources are a source of enterprise innovation, an enterprise needs to possess innovative human resource management in order to effectively conduct R&D, produce innovative products, and expand into new markets. Appleby and Mavin (2000) proposed that in organizational behavior, personnel management and innovation, technology management are closely related to each other. If an enterprise can fit human resource management into enterprise strategies, it can gain innovational and variation advantages compare to competitors. Wiig (2000) pointed out that human resource management can be used in searching for and attracting personnel, inspiring and rewarding employees, designing an open, sharing environment, and fostering creative and innovative capabilities among employees. Barney and Wright (1998) proposed that from the viewpoint of strategic human resource management, human resource management is an effective tool for an organization in cultivating intangible knowledge and resources, which can help an organization to maintain long lasting competitive advantage. Hayton (2005) also argued that human resource management strategy can be linked to the organizational culture and entrepreneurial spirit of the enterprise. He also found that human resource strategy is an important tool for creating organizational culture and reinforcing organizational innovation. Laursen and Foss (2001) found that the internal human resource management activities of an organization, such as training, knowledge sharing, or external training, all of which can advance information knowledge communications and elevate innovative capabilities. Thus, we hypothesize:

H5 : The level of HR practices in R&D professtionls is positively related to organizational innovative capability

Organizational innovation means to produce new ideas, products, services or manufacturing procedures. Through learning processes, an organization can store knowledge and create innovations. Learning in an organization is not simply mimicking and coping, but is constant innovation in an organization (Cohen and Levinthal, 1990). Exercising human resource techniques and knowledge can enhance the growth of an enterprise, while at the same time an enterprise can improve management by enhancing human capital and human resource development and application (Rauch, Frese, and Utsch, 2005). Human capital, which includes value creation skills, the talent and capability of the labor force, is the basic element for an

enterprise in obtaining competitive advantage (Leadbeater, 2000). Hence Hsu (2007) considered that commitment to learning can lead to better organizational innovation, since an enterprise that possesses learning capability will allow employees to effectively create and apply new knowledge, and values its human capital. Thus this research assumes organizational learning capability will affect organizational innovative capability through the mediation of human capital. We thus hypothesize:

H6 : Human capital mediates the relationship between organizational learning capability and organizational innovative capability.

In order to create innovation in the manufacturing procedures of an enterprise, human resource management activities should involve collaboration with manufacturing procedure innovation. This can include training activities to help learn new skills, or group oriented achievement evaluation that allows employees to understand innovational target and content of procedures (Ittner and Larcher, 1997). Pedler, Burgoyne, and Boydell (1991) proposed a cyclical concept aimed at organizational management activity, and considered the cycle of every organizational management activity to be a learning activity. They also pointed out that organizational learning can be coordinated and integrated by the human resource development department, enabling the entire organization to conduct learning at the same pace toward strategic targets. Moreover, they observed, human resource development related personnel can play a strategic role, connecting individual learning procedures with organizational procedures, and utilizing enterprise resources to development strategic capabilities and construct core specialties.

For an enterprise with high innovative capability, the learning-while-working effect will occur, as for other competitors, for knowledge that cannot be purchased from the market and facing innovative capability that is hard to copy. Moreover, such know-how will be introduced into R&D activities by the organization, enabling the organization to surpass its competitors in innovations (Cavusgil, Calantone, and Zhao, 2003). This research proposes that when an industry faces a rapidly changing external environment, the ability of the human resources department to manage organizational learning capability is a key factor in the ability of the organization to innovate. We thus hypothesize:

H7 : HR practices in R & D professionals mediate the relationship between organizational learning capability and organizational innovative capability.

METHODOLOGY

Sample and Data Collection

The data for this study were obtained from 119 companies awarded the Innovative Research Award between 2002-2004 by the Small and Medium Enterprise Administration, Ministry of Economic Affairs, along with 276 companies approved for developing new technologies in 2005 by the Department of Industrial Technology, for a total of 395 companies. A survey team distributed survey packages to each participating company by mail in May in 2007. Each survey package contained two separate questionnaires administered to HR managers and R & D managers. A cover letter attached to each questionnaire explained the objective of the survey and assured respondents of the confidentiality of their responses and the voluntary nature of participation in the survey. For each company, the human resource manager questionnaire requested the HR managers to provide data on human capital and human resource practices. The R & D managers questionnaire was administered to R & D manager to rate the organizational learning capability and innovation capability. Completed questionnaires were returned sealed in self-addressed envelopes to the human resource manager of each participating company.

Of the 395 survey packages distributed, 166 were returned. After deleting uncompleted questionnaires and records with unmatched HR-R & D manager dyads, we had 161 valid questionnaires. 30.2% were from companies with capital under NTD $10 million, 44.7% (72 companies) had revenues of under NTD $1 billion. Fifty-seven companies (35.4%) had fewer than 100 employees.

Measures

Organizational Learning Capability was measured using the three dimensions developed by Baker and Sinkula (1999): commitment to learning, shared vision, and open-mindedness. The scale was assessed using ten items. These items were summed to arrive at an organizational learning capability score. Responses are indicated on five-point Likert scale (1=strongly disagree, 5=strongly agree), with such items as "Learning in my organization is seen as a key characteristic necessary to guarantee organizational survival" and "My organization expresses well concept of who we are and where we are going as a business unit".

Human capital was measured using twelve items developed by Lepak and Snell (2002), covering the following two dimensions: value and uniqueness. The strategic value of human capital refers to its potential to improve the efficiency and effectiveness of the firm, exploit market opportunities, and neutralize potential threats (Barney, 1991; Ulrich and Lake, 1991). The uniqueness of human capital refers to the degree to which it is rare, specialized and, in the extreme, firm-specific (Barney, 1991). These two indices were measured on a 5-point Likert scale (1=strongly disagree, 5=strongly agree), with sample items as "Employees have skills that

**Proceedings of 2014 International Conference on
Technology Innovation and Industrial Management
28th-30th May 2014, Seoul, South Korea**

create customer value" and "Employees have skills that are unique to our organization." HR practices in R & D professionals was measured based using the instrument adapted by Jaw and Liu (2003) and Kochanski, Mastropolo, and Ledford (2003). We used items that covered the three dimensions of HR practices in R & D professionals: comprehensive training, - 8 supporting incentive compensation, career development and performance emphasis.

Sixteen items were selected for the final measure. These three indices were measured on a 5-point Likert scale (1=strongly disagree, 5=strongly agree), with sample items as "Extensive training programs are provided for individuals in this job" and "The benefits my company provides meet my needs."

Organizational innovation capability was measured using the two dimensions proposed by Damanpour (1991), technical innovation and management innovation. Twelve items were used in the final measure. Responses are indicated on five-point Likert scale (1=strongly disagree, 5=strongly agree), with such items as "Pioneer disposition to introduce new process" and "Search of innovative compensation management systems to motivate the employees. "

Construct Analysis

Confirmatory factor analysis was employed to confirm the heterogeneity of organizational learning capability, human capital, HR practices in R & D professionals, and organizational innovation capability. AMOS 5.0 software was used. Maximum likelihood estimation (MLE) was used for the variable calculation in order to observe the suitability of the various constructs. The $\chi 2$, GFI, AGFI, CFI and RMSR of the various constructs are shown in Table 1. The measures demonstrated adequate reliability and convergent validity.

The reliability for all measures exceeded the preferred level of 0.7 (Nunnaly and Bernstein, 1994). Adequate convergent validity was demonstrated in each of the four measurement models, which showed no evidence of cross loadings and demonstrated t-values in excess of 1.96 for each item loading (Anderson and Gerbing, 1988).

Table 1 Results of the Confirmatory Factor Analysis

Construct	Alpha	χ^2 (p-value)	GFI	AGFI	CFI	RMSR
Organizational learning capability						
Commitment to learning	0.835	49.47(0.025)	0.943	0.902	0.967	0.030
Shared vision	0.756					
Open-mindedness	0.841					
Human capital						
Value	0.827	53.01(0.001)	0.933	0.884	0.957	0.025
Uniqueness	0.842					
HR practices in R & D professionals						
Comprehensive training	0.882					
Supporting incentive compensation	0.830	129.04(0.031)	0.917	0.888	0.970	0.031
Career development and Performance emphasis	0.928					
Innovation Capability						
Technical innovation	0.774	59.76(0.004)	0.933	0.852	0.961	0.034
Management innovation	0.907					

Discriminate validity is assessment of the extent to which independent assessment methods diverge in their measurement of traits (Byrne, 1998). Anderson (1987) argued that discriminate validity could be assessed by examining the 95 percent confidence intervals (plus or minus 1.96 standard errors) around all possible pair-wise factor correlations to see whether they contain 1.0. However, none of the confidence intervals contained 1.0, indicating good - 9 -discriminate validity among the constructs.

RESULTS

Table 2 reports means, standard deviations, and correlations. The correlations among the dimensions of organizational learning capability range from 0.39 to 0.57, which shows that the three dimensions measure different facets of organizational learning capability. The other correlations reported in Table 2 are all moderate in magnitude. The correlations among human capital (value, uniqueness), HR practices in R & D professionals (comprehensive training, supporting incentive compensation, career development and performance emphasis) and innovation capability (technological innovation, management innovation) measure range from 0.22-0.65.

Table 2. Means, Standard Deviations, and Correlations for All Variables (N=161)

Variables	M	SD	1	2	3	4	5	6	7	8	9
1.Commitment to learning	3.98	0.67	1.00								
2.Shared vision	3.88	0.58	0.46**	1.00							
3.Open-mindedness	3.84	0.67	0.39**	0.57**	1.00						
4.Value	3.79	0.55	0.35**	0.43**	0.38**	1.00					
5.uniqueness	3.66	0.69	0.30**	0.27**	0.28**	0.50**	1.00				
6.comprehensive training	3.73	0.65	0.41**	0.47**	0.35**	0.46**	0.28**	1.00			
7.Supporting incentive	3.48	0.81	0.21**	0.34**	0.30**	0.36**	0.25**	0.62**	1.00		
8.career development and performance emphasis	3.45	0.69	0.27**	0.52**	0.24**	0.42**	0.37**	0.57**	0.44**	1.00	
9.Technical innovation	3.86	0.61	0.22**	0.29**	0.32**	0.38**	0.27**	0.40**	0.24**	0.29**	1.00
10.Management innovation	3.48	0.69	0.29**	0.48**	0.53**	0.65**	0.36**	0.57**	0.44**	0.44**	0.41**

**p(two-tailed)<0.01

Assessment of Model Fit and Path Significance

We examined the overall fit of the model using several fit indices. Our model had an adequate fit to the data, as indicated by chi-square/df value of 2.104. The GFI assesses how well the hypothesized model reproduces the sample data without the reference model. A good GFI should be 0.9 or higher. Our model's GFI of 0.94 thus shows a good fit. In addition, the comparative fit index (CFI=0.944), normed fit index (NFI=0.901), mean square residual (RMR=0.024), and root-mean-square error of approximation (RMSEA=0.083) all suggest that our model fits that data well.

Table 3 and Figure 1 provide the maximum likelihood parameter estimates for this research model. Based on Table 3, we found that the organizational learning capability of SMEs had a significant positive influence on human capital ($\gamma 11=0.670$, $p<0.001$), which supports H1. Indicating the higher the organizational learning capability of an enterprise, the more the human capital can be stored. Obviously organizational learning can advance the accomplishment of personnel training programs, at the same time, cultivating the uniqueness and professional capabilities of employees, in order to accumulate human capital for - 10 -organizations (Buren, 1999).

Table 3 Results of the LISREL Testing

1.Key Parameter Estimates		
Hypothesized Paths	Direct Effects	C.R.
Organizational learning capability →Human capital ($\gamma 11$)	0.670	5.706*
Organizational learning capability →HR practices in R & D professionals ($\gamma 21$)	0.712	5.879*
Organizational learning capability →Innovation Capability ($\gamma 31$)	0.226	1.263
Human capital→ Innovation Capability ($\beta 31$)	0.527	3.094*
HR practices in R & D professionals→ Innovation Capability ($\beta 32$)	0.357	2.697*
2.Fit Indices for the Structural Model		
Chi-square=157.482（p-value=0.000）		
GFI=0.935		
AGFI=0.881		
RMR=0.024		
RMSEA=0.083		
CFI=0.944		
NFI=0.901		

Note：* C.R.>1.96；using a significance level of 0.05, critical rations that exceed 1.96 are significant

The organizational learning capability of SMEs has a significant effect on HR practices in R & D professionals (γ21=0.712，p<0.001), indicating that the stronger the organizational learning capability an enterprise possesses, the easier is the HR practices in R & D professionals reinforcement which supports H2. As Smith (2004) proposed, the existence of an organizational learning culture also includes encouraging learning from inside the organization itself and among individuals within groups. Thus the value and effectiveness of human resource development activity can be assured through learning.

The organizational learning capability of SMEs appears to have no significant effect on innovative capability (γ31=0.226, p>0.05). H3 is thus not supported. Cohen and Levinthal (1990), along with Cavusgil, Calantone, and Zhao (2003), argue that enterprise absorption and assimilation of the external environment through learning should help internal innovation activities. However, this research found that learning capability had no significant effect on innovative capability. One reason for this might be that when the entire environment is perpetually unstable, and so many internal and external factors are capable of impacting innovation within the firm, management may insulate the decision-making process from the mechanisms that allow learning to occur. Further, nearly all Taiwanese SMEs are family-run, which helps insulate organizational learning from innovation, since the decision making powers are tightly held by the founder and a small circle of close friends and relatives. Thus learning may not directly affect innovative capability.

Human capital accumulation and storage of SMEs has a significant positive effect on innovative capability (β31=0.527，p<0.001), supporting H4. This shows that the richer human capital of the enterprises, the easier the elevation of organizational innovative capability. As Guthrie

(2001) observed, rich human capital can not only create innovative ideas for the firm,but can also change organizational procedures, and promptly resolve customer problems. At the same time, this research found that HR practices in R & D professionals of SMEs had a significant positive effect on innovative capability ($\beta_{32}=0.357$, $p<0.01$), supporting H5. This appears to indicate that better HR practices in R & D professionals, raises organizational innovative capability. Thus, human resource management can be used in recruiting personnel, inspiring and rewarding employees, and also designing an open, sharing environment that helps employees create and nurture innovation capabilities (Wiig, 2000).

Figure 1 depicts the results of the path analysis and demonstrates the relationship between the exogenous and endogenous variables.

Note：*p<0.05 Dotted line indicates a non-significant path. Values shown are parameter estimates.

Figure 1: Structural Equation Model

As Figure 1 shows, we found that organizational learning capability of SMEs has no significant direct effect on innovative capability ($\gamma_{31}=0.226$, $p>0.05$). However, the organizational learning capability of SMEs has a direct effect on human capital ($\gamma_{11}=0.670$, $p<0.001$); at the same time, human capital has a direct effect on organizational innovative capability ($\beta_{31}=0.527$，$p<0.001$). The Sobel-test shows that the organizational learning capability of SMEs has a significant indirect effect on innovative capability (t=2.72, $p<0.01$), in which the indirect influence is 0.353 ($\gamma_{11}\beta_{31}=0.670*0.527$). Thus, the organizational learning capability of SMEs appears to increase

the organizational innovative capability through human capital accumulation and storage, supporting H6. The organizational learning capability of SMEs has a direct effect on HR practices in R & D professionals ($\gamma21=0.712$, p<0.001), and HR practices in R & D professionals has a direct effect on organizational innovation capability ($\beta32=0.357$, p<0.01). Using the Sobel-test, we found that the organizational learning capability of SMEs has a significant indirect effect on their innovative capability (t=2.45, p<0.05), inwhich the indirect influence is 0.254 ($\gamma21\beta32=0.712*0.357$). Obviously the organizational learning capability of an enterprise will affect organizational innovative capability through the mediating effects of HR practices in R & D professionals. Thus H7 was supported.

DISCUSSION

This research investigated organizational learning capabilities, human capital reserves, and HR practices in R & D professionals, and their effects on the innovative capability of an enterprise. At the same time, we explored how the organizational learning capability affects innovative capability through the intermediaries of human capital and HR practices in R & D professionals. We found that an enterprise with stronger organizational learning capability can easily retain its human capital, as well as strengthen its HR practices in R & D professionals.

Therefore, human capital is the most dynamic asset of a firm. Without human capital, none of the value creation activity in the company can be conducted. Thus a successful learning organization needs to possess a continuous learning culture and capability, and to provide employees with an environment conducive to learning in order to accelerate the learning of all organization members and constantly upgrade organizational human capital, as well as retaining human capital within the organization (Dixon, 1994; Kamoche and Mueller, 1998).

Furthermore, from the viewpoint of intellectual capital management, human capital management must emphasized retention. Management must find valuable human capital and keep them within the organization, while at the same time, convert the knowledge and capability of employees into competitive advantage for the enterprise. Since human capital of an enterprise can not easily been copied by competitors, the higher the level of human resources applied to high value added jobs, the higher the profit that can be created, as well as the larger the contribution to competitive advantage and core capability of the organization (Lynn, 2000; Appleby and Mavin, 2000; Hayton, 2005). Currently, Taiwanese SMEs are facing risks such as short product life cycles, fast changing technological development, high management risks, severe competition and turbulence in the external environmental. Therefore, an enterprise must utilize inspiring metrics to motivate the maximum production from human resources applied to R&D. We found that when SMEs emphasized HR practices in R & D professionals, in addition to developing high value added products and creating more efficient production technologies and innovational management

methods to upgrade the core capabilities of the enterprise, the innovative capabilities of the organization may also be enhanced.

Finally, this research took the ideas of Pedler, Burgoyne, and Boydell (1991), and Rauch, Frese, and Utsch (2005) one step further, empirically investigating organizational learning capability and its effect on innovative capability, human capital and HR practices in R & D professionals. In the knowledge economy era, learning capability is the necessary device for storing and applying knowledge, and superior human capital and good human resource management of R&D professionals are the best catalysts for advancing learning effectiveness.

At the same time, for an enterprise to innovate and make progress, it must conduct constant learning. Applications of human resource management techniques in R & D and knowledgecan enhance the growth of an enterprise. Moreover, an enterprise can create successful opportunity management by enhancing human capital and human resource development.

Thus when an enterprise faces a fast changing environment, strengthening its learning capability and enhancing its innovative capability is an important consequence of the indirect influences of human capital and HR practices in R & D professionals.

CONCLUSIONS AND IMPLICATIONS

In the current knowledge economy era, how to manage intellectual capital and create organizational competitive advantage is a topic of intense interest among both scholars and practitioners. The greatest core value for enterprises comes from the wisdom and knowledge of its employees. Thus, an enterprise that possesses human capital advantages will create superior enterprise value. Therefore, SMEs should strive to retain human capital with unique skills and strategic value to the organization, making the most of its human capital to create competitive advantage.

To strengthen the learning capability of SMEs, they should consider learning as a fundamental value of an organization. At the same time, they should engage in creative thinking and share its future development directions and vision with its employees.

With Taiwan's economy steadily becoming more knowledge based, economic growth must be maintained through inter-industrial R&D and proactive technology R&D. Cultivating R&D personnel has become a important tactic for technology development. SMEs must actively train professional R&D personnel, and encourage knowledge spreading and application.

This research found organizational learning capability will not directly affect innovative capability, findings totally different from those of Stata (1989), Cohen and Levinthal (1990), and Cavusgil, Calantone, and Zhao (2003). We found that organizational learning capability must act through the intermediaries of human capital and HR practices in R & D professionals to affect organizational innovative capability. Therefore, SMEs must absorb and assimilate the external environment by organizational learning, and upgrade their human resource practices in the R&D area to enhance organizational benefits.

Future research might examine the extent to which e-organizational learning, technological transformation, enterprise transform strategies, and human resource transformation moderate the relationship between organizational learning capability and innovative capability. At the same time, objective performance data should be collected in order to further examine whether innovative capability increases will affect organizational performance.

REFERENCES

1. Anderson, J. C.（1987）. "An Approach for Confirmation Measurement and Structural Equation Modeling of Organizational Properties," Management Sciences 33, 525-541.
2. Appleby, A., and Mavin, S. (2000). "Innovation Not Imitation: Human Resource Strategy and the Impact on Word-class Status," Total Quality Management 11(6), 554-561.
3. Argyris, C., and Schön, D. A.（1978）. Organizational Learning: A Theory of Action Perspective. Reading（MA）: Addison-Wesley.
4. Baker, W. E., and Sinkula, J. M. (1999). "The Synergistic Effect of Market Orientation and Learning Orientation on Organizational Performance," Academy of Marketing Science 27(4), 411-427.
5. Barney, J., and Wright P. M. (1998). "On Becoming a Strategic Partner: The Role of Human Resources in Gaining Competitive Advantage," Human Resource Management 37(1), 31-46.
6. Barney, J. B. (1991). "Firm Resources and Sustained Competitive Advantage," Journal of Management 17(1), 99-120.
7. Bartlett, C.A., and Ghoshal, S. (2002). Transnational Management: Text, Cases and Readings in Cross Border Management. 3rd ed., London, McGraw-Hill Hihger Education.
8. Buren, M. E. (1999). "A Yardstick for Knowledge Management," Training & Development, 71-78.
9. Byrne, B. M.（1998）. Structural Equation Modeling with LISREL, PRELIS, and SIMPLIS. Mahwah, NJ: Lawrence Erlbaum Associates.

10. Calantone, R. J., Cavusgil, S. T., and Zhao, Y. (2002). "Learning Orientation, Firm Innovation Capability, and Firm Performance," Industrial Marketing Management 3, 515-524.

11. Capaldo, G., Iandoli, L., Raffa, M., and Zollo, G. (2003). "The Evaluation of Innovation Capabilities in Small Software Firms: A Methodological Approach," Small Business Economics 21(4), 343-358.

12. Cavusgil, S. T., Calantone, R. J., and Zhao, Y. (2003). "Tacit Knowledge Transfer and Firm Innovation Capability," The Journal of Business & Industrial Marketing 18(1), 6-21.

13. Cohen, W. M., and Levinthal, D. A. (1990). "Absorptive Capacity: A New Perspective on Learning and Innovation," Administrative Science Quarterly 35(1), 128-153.

14. Damanpour, F.（1991）. "Organizational Innovation: A Meta-analysis of Effects of Determinants and moderators," Academy of Management Journal 34(3), 555-590.

15. Dixon, N. M. (1994). The Organizational Learning Cycle: How We Can Learn Collectively Hampshie. England: Gower.

16. Dyer, L.(1984). "Study Resource Strategy: An Approach and an Agenda," Industrial Relations 23, 156-169.

17. Edvinssson, L., and Malone, M. S. (1997). Intellectual capital. New York: Harper Collins Publishing, Inc.

18. Guthrie J. (2001). "The Management Measurement and the Reporting of Intellectual Capital," Journal of Intellectual Capital 2(1), 27-41.

19. Grant, R. M.（1996）. "Toward a Knowledge-based Theory of the Firm," Strategic Management Journal 17, 109-122.

20. Hayton J. C. (2005). "Promoting Corporate Entrepreneurship through Human Resource Management Practices: A Review of Empirical Research," Human Resource Management Review 15(1), 21-41.

21. Hitt, M. A., Bierman, L., Shimizu, K., and Kochhar, R. (2001). "Direct and Moderating Effects of Human Capital on Strategy and Performance in Professional Service Firms: A Resource-Based Perspective," Academy of Management Journal 44, 13-28.

22. Hsu, S. H.（2007）. "Human Capital, Organizational Learning, Network Resources and Organizational Innovativeness," Total Quality Management 18(9), 983-998.

23. Huber, G. P.（1991）. "Organizational Learning: The Contributing Processes and the Literatures," Organization Science 2(1), 88-115.

24. Hurley, R. F., and Hult, G. T. M. (1998). "Innovation, Market Orientation, and Organizational Learning: An Integration and Empirical Examination," Journal of Marketing 62(3), 42-55.

25. Ittner, C. D. and Larcker, D. F.（1997）. "Product Development Cycle Time and Organizational Performance," Journal of Marketing Research 34, 13-23.

26. Jaw, B. S., and Liu, W.（2003）. "Promoting Organizational Learning and Self-renewal in Taiwanese Companies: The Role of HRM," Human Resource Management 42(3), 223-241.

27. Jerez-Gómez, P., Céspedes-Lorente, J., and Valle-Cabrera, R.（2005）. "Organizational Learning Capability: A Proposal of Measurement," Journal of Business Research 58, 715-725.

28. Kamoche, K., and Mueller, F. (1998). "Human Resource Management and the Appropriation Learning Perspective," Human Relations 51, 1033-1060.

29. Kochanski, J., Mastropolo, P., and Ledford, G. (2003). "People Solutions for R&D," Research Technology Management 46(1), 53-56.

30. Lado, A. A., and Wilson, M. C.(1994). "Human Resource Systems and Sustained Competitive Advantage: Competency-Base Perspective," Academy of Management Review 19, 699-727.

31. Laursen, K., and Foss, N. J.（2003）. "New Human Resource Management Practices, Complementarities and the Impact on Innovation Performance," Journal of Economics 27(2), 243-263.

32. Leadbeater, C. (2000). Sirhumphrey Needs Venture Capital. New Statesman. London: 27, 13, Iss. 633.

33. Lepak, D. P., and Snell, S. A. (2002). "Examining the Human Resource Architecture: The Relationships among Human Capital, Employment, and Human Resource Configurations," Journal of Management 28(4), 517-543.

34. Liao, L. H, Fei, W. C., and Liu, C. T.（2008）. "Relationships between Knowledge Inertia, Organizational Learning and Organization Innovation," Technovation 28, 183-195.

35. Lindell, M. K., and Whitney, D. J.（2001）. "Accounting for Common Method Variance in Cross Sectional Research Designs," Journal of Applied Psychology 86(1), 114-121.

36. Lu, Q., and Lazonick, W. （2001）. "The Organization of Innovation in Transitional Economy: Business and Government in Chinese Electric Publishing," Research Policy 30(1), 55-77.

37. Lynn, B. E. (2000). "Intellectual Capital: Unearthing Hidden Value by Managing Intellectual Assets, " Ivey Business Journal 64(3), 48-52.

38. Nahapiet, J., and Ghoshal, S.（1998）. "Social Capital, Intellectual Capital, and the Organizational Advantage," Academy of Management Review 23(2), 242-265.

39. Nevis, E. C., DiBella, A. J., and Gould, J. M.（1995）. "Understanding Organizations as Learning Systems," Sloan Management Review, Winter, 73-85.

40. Nonaka, I. and Takeuchi, H. (1995). The Knowledge-Creating Company. Oxford University Press.

41. Nunnaly, J. C., and Bernstein, I. H.（1994）. Psychometric Theory. McGraw-Hill, New York, NY.

42. Pedler, M. (1997). The Learning Company: A Strategy for Sustainable Development. 2nd ed, McGraw-Hill, London.

43. Pedler, M., Burgoyne, J., and Boydell, T. (1991). The Learning Company: A Strategy for Sustainable Development. London: McGraw-Hill.

44. Pfeffer, J.(1994). Competitive Advantage through People: Understanding the Power of Work Force. Boston: HBS Press.

45. Podaskoff, P. M., and Organ, D. W. (1986). "Self-reports in Organizational Research: Problems and Prospects," Journal of Management 12(4), 531-544.

46. Probst, G., Raub, S., and Romhardt, K. (2000). Managing Knowledge. New York, NY: John Wiley and Sons Inc.

47. Pucik, V.(1988). "Strategic Alliances, Organizational Learning, and Competitive Advantage: The HRM Agenda," Human Resource Management 27(1), 77-93.

48. Rauch, A., Frese, M. and Utsch, A. (2005). Effects of Human Capital and Long-term Human Resources and Utilization on Employment Growth of Small-scale Businesses: A Causal Analysis," Entrepreneurship Theory and Practice 30(4), 681-698.

49. Senge, P. M.（1990）. The Fifth Discipline: Art and Practice of the Learning Organization. New York: Doubleday.

50. Sinkula, J. M., Baker W. E., and Noordewier, T. (1997). "Framework for Market-based Organizational Learning: Linking Values, Knowledge, and Behavior," Journal of the Academy of Marketing Science 25(4), 305-318.

51. Smith, R. D.（2004）. Beyond the Bar: Scheduling Preliminary Engineering and Launching a New Project. AACE International Transactions, Morgantown.

52. Stata, R. (1989). "Organizational Learning－The Key to Management Innovation," Sloan Management Review 10(1), 63-74.

53. Stewart, T. A. (1997). Intellectual Capital: The New Wealth of Organizations. New York: Bantam Doubleday Dell Publishing Group, Inc.

54. Ulrich, D. (1997). "Measuring Human Resources: An Overview of Practice and a Prescription for Results," Human Resource Management 36(3), 303-320.

55. Ulrich, D., and Lake, D.（1991）. "Organizational Capability: Creating Competitive Advantage," Academy of Management Executive 5(1), 77-92.

56. Watkins, K. E., and Marsick, V. J. (1993). Sculpting the Learning Organization: Lessons in the Art and Science of Systemic Change. San Francisco: Jossey-Bass.

57. Wayne, S.J., Shore, L.M., and Liden, R.C. (1997). "Perceived Organizational Support and Leader-member Exchange: A Social Exchange Perspective," Academy of Management Journal 40, 82-111.

58. Wiig, K. (2000). Knowledge Management: An Emergency Discipline Rooted in a Long History. In C. Despres and D. Chauvel (eds.), Knowledge horizons: The present and the promise of knowledge management (pp.4-26). Boston: Butterworth Heinemann.
59. Wright, P. M., and McMahan, G. C. (1992). "Theoretical Perspectives for Strategic JRM," Journal of Management 18(2), 295-320.

EXPLORING SUFFICIENCY CONDITIONS FOR ENTREPRENEURIAL ENVIRONMENT AND COUNSELING ACTIVITIES ON ENTREPRENEURIAL PERFORMANCE

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ABSTRACT

This empirical study aims to explore sufficiency conditions for Entrepreneurial Resources and Counseling Activities on Entrepreneurial Performance. The study collected 111 questionnaires from entrepreneurs in Taiwan and applied fuzzy set qualitative comparative analysis (fs/QCA) to explore the sufficiency conditions for entrepreneurial environment and counseling activities on entrepreneurial performance. In a regression analysis, there was no significant finding regarding the effects of entrepreneurial counseling on entrepreneurial performance. However, the fs/QCA analysis results show there is high causal relevance of entrepreneurial environment, entrepreneurial counseling and a combination of these two on entrepreneurial performance. Specifically, when entrepreneurial environment are available, the results (Y) of entrepreneurial performance are probably yielded. When entrepreneurial counseling is available, entrepreneurial performance can be created. Finally, when a combination of entrepreneurial environment and entrepreneurial counseling are available, entrepreneurial performance can be yielded. Therefore, a low correlation between the variables does not preclude the existence of relationships of necessity and/or sufficiency. Fs/QCA leads to a fuller understanding of the conditions under which the outcome occurs.

Keywords: Entrepreneur Environment, Entrepreneur Counseling activities, Entrepreneur Performance, fuzzy set qualitative comparative analysis (fs/QCA)

INTRODUCTION

The aim is to explore sufficiency conditions for entrepreneurial environment and counseling activities on entrepreneurial performance. The establishment of new businesses can generate economic value, but can also be equipped with risks, uncertainties and a high degree of failure.

The studies show that 15-20% of entrepreneurs did not utilize the entrepreneurial resources available during the establishment of their business, such as information on laws and regulations, taxation, finances and technology etc. (Lundström and Kremel, 2011). Zhao et al. (2010) further believe that in the process of counseling and training activities, more efforts should be made to understand the personality of the entrepreneurs. Taticchi et al. (2009) holds that entrepreneurial competitiveness lies in the utilization of resources, such as strategic partners, and network technology to create value, rather than the type of industry or company. Wu (2009) believes that the unique method of allocation of entrepreneurial resources for entrepreneurs determines the development and the establishment of businesses.

In addition, due to their lack of management knowledge, the chance of failure for these entrepreneurs is increasing. Therefore, the attitude of entrepreneurs towards the resources on offer affects their entrepreneurial performance. Eileen et al. (1993) also point out that to strengthen the understanding and counseling activities, entrepreneurial experience is quite significant. Karunanithy and Jeyaraman (2013) believed that entrepreneurial counseling activities are vital necessities that can improve entrepreneurial performance and enhance entrepreneurial abilities. For example, in the early stage of the establishment of a business, entrepreneurs can do everything themselves. With an increase in business, however, and the establishment of an effective management mechanism through the entrepreneurial counseling activities, the workload can be shared and cooperation is needed to ensure that employees strive for different goals. In addition, they have to locate the reasons for any previous mistakes rather than repeat the same mistakes. Through appropriate counseling activities, entrepreneurs are encouraged to discover their own abilities and goals (Karunanithy and Jeyaraman, 2013). Therefore, during the establishment of a business, related entrepreneurial counseling activities can promote the knowledge and skills of entrepreneurs to reduce any risk and uncertainties, boost their confidence, reduce the fear of business failure and promote the chances for success (Brown, Doyle, Lewis, Mallette and Young, 2002; Devi,2011; Sharma et al, 2012; Karunanithy and Jeyaraman, 2013).

In summary, entrepreneurial counseling activities are of great importance and enhance the improvement of entrepreneurial results. At present, many entrepreneurial counseling activities not only promote the knowledge and skills of entrepreneurs, but also offer new opportunities for new businesses and counseling for enterprise planning, which are vital to entrepreneurs (Kevin, 1999). However, the reality is that the importance of entrepreneurial counseling activities is rarely highlighted. This study plans to explore whether a combination of entrepreneurial resources and entrepreneurial counseling are available, entrepreneurial performance can be yielded.

LITERATRUE REVIEW

This section will study the concepts and implications of the entrepreneurial environment and the entrepreneurial counseling activities and their related research results.

Entrepreneurial Environment

Entrepreneurial environment refers to combination of factors that play a role in the development of entrepreneurship (Fogel, 2001). Empirical studies of various countries show that countries that keep rules and regulations at a minimum, offer tax and other incentives, and provide training and counseling services to start-up entrepreneurs increase the likelihood of new venture development (Dana, 1990). The above implies entrepreneurial environment is defined as resources. Srivastava et al., (1998) believe that resources are defined as "market-based assets" and also defined as "the resources generated by the interaction between internal and external environment in enterprises and could create values for customers and financial values". Barney (1991) classified the enterprises resources into three types: the first type is Physical Capital Resources (PCR) consisting of the utilization of practical technologies; the second type is Human Capital Resources (HCR) and includes experience, intelligence counseling activities, relationship, and personal management insight; the final one is Organizational Capital Resources (OCR) and contains formal and informal planning, the non-formal relationship inside the company and the relationship between the company and the external environment. Grant (1991) proposed resource-based theory and believed that the profitability of companies relies on their attractiveness and competitive advantages. The basis for the competitive advantages comes from their resources.

In recent years, in the study of entrepreneurial management, resources have been developed as the key factor determining whether the company will acquire success or not (Kralj and Markič, 2008). Entrepreneurial environment are the tangible and intangible resources that can offer the biggest assistance with laws and regulations for entrepreneurs with the minimum effort. These could assist in offering taxation reduction and various financial resources, technologies, the utilization of labor forces, and entrepreneurial counseling activities (Dana 1987, 1990; Lichtenstein and Brush, 2001; Dollingers, 2003). In particular, in the early stage of a new business, intangible assets, such as technology and management, etc. are much more important than tangible assets (Lichtenstein and Brush, 2001).

In summary, this study defines entrepreneurial environment as the tangible and intangible resources that play the key role to help entrepreneurs achieve their entrepreneurial goals.

Entrepreneur Counseling Activities

Recent researches suggest that entrepreneurship is embedded in a social context capacity

(Gourova et al., 2009). For each entrepreneur, knowledge plays a key role in their business and determines the effectiveness of their entrepreneurship (Mocanu et al., 2010). Counseling activities enable entrepreneurs to learn innovative management, develop the implicit knowledge of entrepreneurship, enhance the knowledge and skills of entrepreneurs and put them into organizational practice so as to reduce the risks and uncertainties that indirectly affect business performance (Kralj and Markič, 2008 ; James et al., 2012).

Entrepreneurial counseling activities refer to the capable consultants that assist at entrepreneur school and determine their entrepreneurial planning to enhance business quality and on-the-job diagnosis etc. (Liang Jinshu, 2010). The importance of entrepreneurial counseling activities is that it can assist enterprises to solve any issues in their business management. In addition, governments can understand the planned enterprise strategies through business counseling activities that promote competitive advantage (Wang, 2009). Nagesh, Narasimha and Murthy (2008) believed that the content of entrepreneurial counseling activities consists of the counseling activities of entrepreneurial motive and possible obstacles in entrepreneurism, the writing of entrepreneurial proposals, marketing, management and leadership etc. However, the counseling policies of entrepreneurial counseling activities are not necessarily in line with the individual needs of the entrepreneurs (Lu & Liang, 2008). The government needs to use professional knowledge during the utilization and operation of the assets of entrepreneurial counseling activities, including the selection of sites, counseling activities for marketing management, technological counseling activities and on-the-job counseling activities etc. (Guo, 2003).

In summary, this study defines entrepreneurial counseling activities as the entrepreneurial abilities used to effectively utilize resources so as to achieve goals through entrepreneurial counseling activities.

METHODOLOGY

In response to the previous research goal, this study focuses on the study of the influence of entrepreneurial counseling activities and entrepreneurial environment on entrepreneurial performance.

Analyses of a quantitative dataset can focus either on identifying patterns of relationships between variables or on examining the configurations of cases that constitute the rows of a data matrix (Chang et al.,2013). Most marketing researchers focus on the former; they are interested in looking at interaction effects, covariation between variables, or examine the "fit" of variable-based patterns with some pre-specified model (Kent and Argouslidis, 2005).
However, such techniques are limited in their ability to handle logical rather than statistical

relationships (Kent & Argouslidis, 2005). They assume that the pattern of relationships between variables is symmetrical, which makes them uneasy to translate some simple, logical expressions, such as Y will be high if X1 and X2 or X3 is high", into conventional linear models (Smithson, 1988). In practice, patterns are commonly triangular (Ragin, 2000), such that while high values of X associate with high values of Y, low values of X associate with the whole range of values for Y. Nevertheless, such asymmetric relationships are not observable using regression-based statistics (Chang et al.,2013).

In examining logical relationships, researchers usually try to identify the occurrence of either necessary or sufficiency conditions. Necessary conditions are simple or complex causal recipes that are found in all instances of the outcome occurring; sufficiency conditions, however, are those conditions wherever they occur, the outcome is present and when the sufficiency condition does not occur, instances of the outcome condition both occur and do not occur(Chang et al.,2013).

Ragin (1987) and Drass and Ragin (1992) provide computer programs based on Boolean algebra that check for all those cases that demonstrate the outcome whether any condition is always (or nearly always, using probabilistic criteria) present to establish logical necessity and, for every logically possible groupings of case configurations whether the outcome is always present (or nearly always present) to establish logical sufficiency (Chang et al.,2013). The process Ragin describes as "qualitative comparative analysis" (QCA) can handle logical complexity conveniently. However, QCA originally was limited to the analysis of binary variables. (Chang et al., 2013).

Fuzzy sets permit membership scores in the interval between 1 and 0, which makes continuum scores available for handling logical complexity of both binary and metric variables(Chang et al.,2013). The technique can distinguish between cases that are "more in" a set than others with a crossover point (of 0.5) for those who are neither 1 nor 0. Different from in conventional analysis, in fuzzy set analysis the distinction between "high" and "low" scores are specific to theoretical and conceptual criteria established by the researcher(Chang et al.,2013). Fuzzy set analysis enables the researcher to draw conclusions about logical relationships, as with QCA, but without having to reduce all the data to crisp binary sets(Chang et al.,2013). When conducting fuzzy set qualitative comparative analysis (fs/QCA), scores for each case concerning the degree of membership of the antecedent factor are plotted against membership scores for the outcome(Chang et al.,2013).

Sample and Data Collection
Based on the over three years of entrepreneurs of the Association of Taiwanese Chain and Franchise Promotion, this study adopts those entrepreneurs on the Phoenix Ventrue plan (issued

by the Council of Labor Affairs, Executive Yuan) as the test samples. 478 questionnaires were distributed on the job website between Dec 2012 to Dec 2013, of which 134 copies were returned. 23 invalid copies were subsequently removed so the number of valid questionnaires is 111. The effective response rate is 23.22%.

Research Argument

In order to achieve the entrepreneurial goal, tangible and intangible assets that play key roles can be used. In response to previous chapters, the vast array of entrepreneurial environment, such as the degree of entrepreneurial management, various financial resources, technology, utilization of labor force, and entrepreneurial counseling activities, can affect entrepreneurial performance. Therefore, this research proposes first argument; e.g., ***Entrepreneurial environment have a significant influence on entrepreneurial performance..***

Fischer and Reuber(2003) believe that entrepreneurial counseling activities could affect the ideas of entrepreneurs regarding entrepreneurship. O'Connor (2007) holds that from the long-term perspective, entrepreneurial counseling activities are the best assistance available in the entrepreneurial process. In summary, in the entrepreneurial process, entrepreneurial environment can affect entrepreneurial performance.. Hence this research will provide second argument; e.g. ***Entrepreneurial counseling activities have a significant influence on entrepreneurial performance.***

Measurement

In this research framework, the dependent variable is entrepreneurial performance and the interdependent variables are entrepreneurial counseling activities and entrepreneurial environment. The operational definition of the variables and the measurement tools are illustrated as follows:

Entrepreneur Environment

Entrepreneur environment in this study refer to the fact that entrepreneurs seek tangible and intangible assets to play key roles to help entrepreneurs achieve goals. Based on the perspective of entrepreneur environment, as proposed by Lichtenstein and Brush (2001) and Dollingers (2003), the measurement tool for entrepreneur environment is adopted in this study. With the help of the empirical experience of entrepreneur counseling activities, 11 items were concluded. A Likert five-point scale is used for measurement as, when the value is higher, its importance is more agreed, and vice versa, with value ranges from 1 point to 5 points. The value of KMO (Kaiser-Meyer-Olkin) in the Entrepreneur Environment Scale is 0.796, and the P value of the Bartlett's spherical test is less than 0.01. After the principal component analysis of EFA (exploratory factor analysis), the value of the characteristics is more than 1; three factors are extracted and the accumulated interpreting variable is 72.683%. Orthogonal rotations are then

adopted to make sure there is no significant correlation between the factors and that the absolute value of the loads of the factors for each item are more than 0.5. When the absolute value of the loads of the factors that do not belong to other items are less than 0.4, constructs can be acquired under the efficiency principle. Consequently, 5 items of factor 1 are relevant to Government Environment, named Government Resources (α=0.861); 4 items of factor 2 are relevant to Technology Environment, named as Technology Environment (α=0.826); and 2 items of factor 3 are relevant to Knowledge Environment, namely Knowledge Resources (α=0.843).

The overall Cronbach's α is 0.871, which is in line with the previous perspective of Saunders et al,(1993) who stated that the coefficient is over 0.7. Therefore, the results are in the range of high level of reliability, which approves a certain degree of stability and internal consistency.

Entrepreneur Counseling Activities

Entrepreneurial counseling activities in this study refer to those entrepreneur counseling activities that could enhance the knowledge and skills of entrepreneurs to reduce risks and uncertainties (James et al., 2012). Based on the perspective of entrepreneurial resources proposed by Nagesh, Narasimha and Murthy (2008), the measurement tool for entrepreneurial resources is adopted in this study. With the help of the empirical experience of entrepreneur counseling activities, 6 items were concluded. A Likert five-point scale was used for measurement as when the value is higher, its importance is more agreed, and vice versa, with values ranging from 1 point to 5 points. The value of KMO (Kaiser-Meyer-Olkin) for the entrepreneurial counseling activities scale is 0.896, and the P value of Bartlett 's spherical test is less than 0.01. After the principal component analysis of EFA (exploratory factor analysis), the value of the characteristics is more than 1. One factor is extracted and the accumulated interpreting variable is 72.14%. Orthogonal rotations are then adopted to ensure there is no correlation among the factors and the absolute value of the loads of the factors for each item is more than 0.5. In addition, when the absolute value of the loads of the factors that do not belong to other items is less than 0.4, constructs can be acquired under the efficiency principle. Six items of factor 1 are relevant to the Counseling Activities System (α=0.916), which is in line with the previous perspective of Saunders et al,(1993) and where the coefficient is over 0.7. Therefore, the results are primarily in the range of high level of reliability, which approves a certain degree of stability and internal consistency.

RESEARCH RESULT

We conduct an analysis first by regression analysis and then fuzzy-set qualitative comparative analysis (fs/QCA) to examine the conditions of such argument.

Regression Analysis

First argument proposed that, in this study the entrepreneurial resources have a significant influence on entrepreneurial performance. As the previous analysis shows, construct factors are extracted to conduct a regression analysis. After regression analysis, the comprehensive adjusted R^2 is 0.045, and the F-Value is 2.729. In terms of the construct of entrepreneur resources, Government resources, Technology resources, and Knowledge resources have all achieved a significant level. Therefore, first argument is approved to be true. In second argument, in terms of entrepreneurial counseling activities have a significant influence on entrepreneurial performance. After regression analysis, the comprehensively adjusted R^2 is 0.039, and the F-Value is 1.736. The results are not significant. Therefore, the second argument is proved to be false.

Fuzzy Set Qualitative Comparative Analysis

The program fuzzy-set/qualitative comparative analysis 2.5 (fs/qca.com) is applied to test alternative sufficient conditions propositions of entrepreneurial resources and entrepreneurial counseling activities to entrepreneur performance in the current study. The first step is to calibrate the data collected in the questionnaire survey. This means all variables need to be given values between 0 and 1. In order to have cases more distinguishable, the analysis includes multiplying the values of all measurements of a variable to make the range of the variable wider, and then proportionally transform those multiplied values into a fuzzy number between 0 and 1. This study uses a Likert scale range from 1 to 5, in the questionnaire to measure entrepreneur environment and Entrepreneurial counseling activities to entrepreneurial performance. For example, entrepreneurial government resources to entrepreneurial performance. After multiplying values of the three items in the dataset, the calibration process would then proportionally transform the value 3125 to 1, and the value 1 to 0. The "crossover" point between satisfied and unsatisfied patients would be 243 in the middle and coded as 0.5 in the fuzzy set. Other categories in this study are created in   parallel fashion. Table1 exhibits the extreme values and the crossover point of each variable in this study. (see table 1)

Table1: the extreme values and the crossover points of each condition

	Government resources	Technology resources	Knowledge resource	Entrepreneurial Environment	Counseling Activities	Calibration of the value
Highest value	3125	625	25	48828125	15625	1
Crossover point	243	81	9	177147	729	0.5
Lowest value	1	1	1	1	1	0

Ragin suggests that a configural model should achieve a consistency ≥ 0.80 to be useful, and the fs/QCA.com permits testing for consistency of models beginning at 0.70(woodside,2013).

Consistency indicates how closely a perfect subset relation of "whales" is approximated by a causal recipe of a configuration of antecedent conditions(woodside,2013). Consistency is first in importance in interpretations in QCA; without relatively high consistency ($\geq$ 0.75 or 0.80) the discussion of coverage is moot. (woodside,2013).

In particular, coverage results from 0.00 to 0.60 are intriguing. (woodside,2013). The higher the unique coverage, the more important the causal configuration, assuming the consistency of the set relationship is high (Ragin 2008). The X-axis is a conjunctive statement representing a complex condition that predicts high values of Y occur for high values of X; no prediction is made for low values of X. The numbers in the lower right and the upper left corner of the graph indicate consistency and coverage. If the upper left number is close to 1.0, this indicates sufficiency; in that case, the lower right corner number displays the coverage. Conversely, a number close to 1.0 in the lower right corner indicates a necessary condition; in that case, the upper left number indicates the coverage.

When testing conditions for their necessity, remember that the threshold for consistency should be high (> .9) and its coverage should not be too low (> .5). Hence, it is important to further assess coverage for conditions with high consistency, since the identification of a necessary condition with low coverage values is unlikely to yield inferential leverage(Mello, 2012).

First argument: When entrepreneurial resources are available, the results (Y) of entrepreneurial performance can be yielded. The findings for consistency (0.938) and coverage (0.834) indicate that the model is useful. (see Figure 1) .

Figure 1

Second argument: When entrepreneurial counseling is available, entrepreneurial performance can be created. The findings for consistency (0.901) and coverage (0.869) indicate that the model is useful and these cases with the outcome are represented by the causal condition. (see Figure 2) .
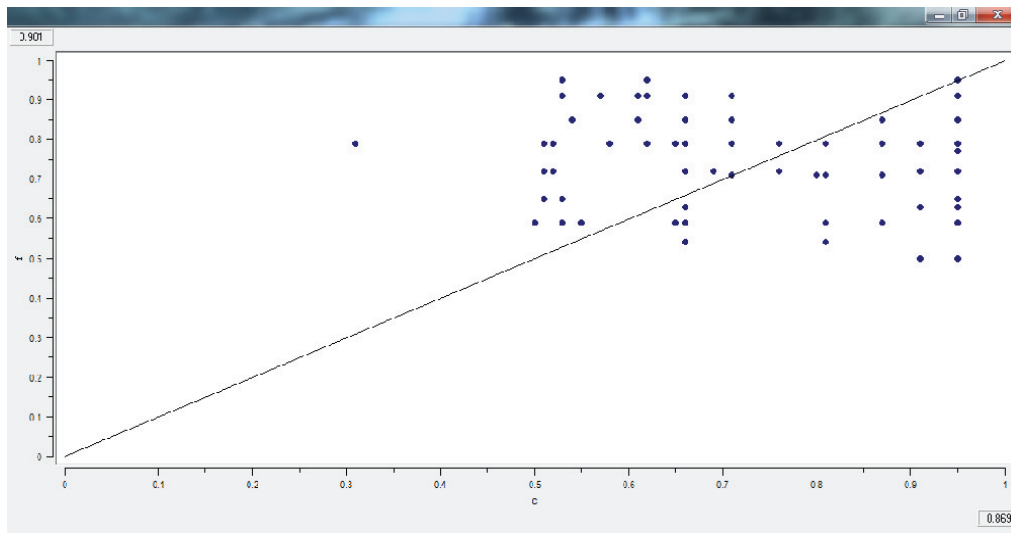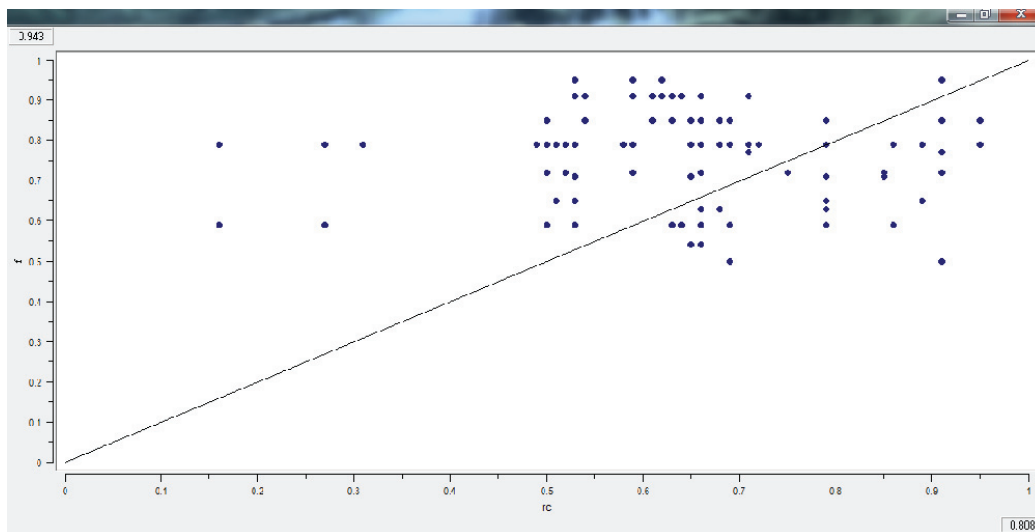

Figure 2

We further explored the third argument that demonstrated when a combination of entrepreneurial resources and entrepreneurial counseling are available, entrepreneurial performance can be yielded.

 The findings for consistency (0.943) and coverage (0.808) indicate that the model is useful. (see Figure3) .

Figure 3

Coverage values are analogous to affect size estimates in statistical hypothesis testing. Coverage assesses the degree to which a cause or causal recipe accounts for instances of the outcome (Woodside, 2010). When several paths to the same outcome exist, the coverage of a given causal combination may be small. Thus, coverage gauges empirical relevance or importance (Woodside, 2010). The higher coverage and consistency figures for the negation fs/QCA analysis are a sign of this (Koole & Vis,2010). To some extent, coverage, which Ragin argues is the equivalent of 'explained variance' in frequentist methods, may give some indication of the 'importance' of a combination, but it is still possible that coverage is high, that is a high proportion of the cases are covered by the expression, but the impact may nevertheless be small(Kent,2008). Based on the fuzzy set qualitative comparative analysis, the results of 0.834, 0.869 and 0.808 for coverage of the combinations of conditions for the output variable means the causal combination of entrepreneurial environment and counseling activities cover 93.8, 90.1 and 94.3 percent of the entrepreneurial performance. In other words, this also means that 6.2, 9.9 and 5.7 percent of entrepreneurial performance may be caused by other conditions or factors (see table 2).

Table2 : Result of fs/QCA

Argument	Number	Consistency	Coverage	Correlation (High/Low)	Effect Size (High/Low)
1	111	0.938	0.834	High	High
2	111	0.901	0.869	High	High
3	111	0.943	0.808	High	High

DISCUSSIONS

In the above study, we adopted regression analysis to testify the significant influence of entrepreneurial environment and entrepreneurial counseling on entrepreneurial performance. The results show that entrepreneurial environment have a significant impact on entrepreneurial performance while there is no significant impact of entrepreneurial counseling on entrepreneurial performance.

In terms of entrepreneur environment, the three factors of government resources, technology resources, and knowledge resources have achieved a significant level, which indicates that entrepreneurial resources have a significant influence on entrepreneur counseling activities. This study is in line with the perspective of Fischer, E., and Reuber, A. R. (2003) who stated that when the degree of emphasis is on the importance of entrepreneurial resources, the degree of recognition for the importance of entrepreneur counseling activities is also relatively higher. Specifically speaking, when an entrepreneur places more emphasis on entrepreneur resources,

they will attract more attention to the influence of entrepreneur counseling activities and the establishment of businesses. It not only recognizes all possible problems and the gap in entrepreneurial resources in the existing entrepreneurship, but also tries to seek out new methods and solutions with the help of entrepreneur counseling activities to solve the issue of resources. Those individuals with relatively rich entrepreneurial resources will not only have an effective response to the market changes, but also their knowledge of entrepreneurship will also offer the enhancement of products or services, which can be used extensively in the entrepreneur fields.

Through fs/QCA, the results show that there is high causal relevance for entrepreneurial environment, entrepreneurial counseling and the combination of these two on entrepreneurial performance (consistency ≥ 0.80), indicating that a single factor or the combination of two factors have sufficiency for the results. Specifically, when entrepreneurial resources are available, the results (Y) of entrepreneurial performance are probably yielded. When entrepreneurial counseling is available, the entrepreneurial performance can be created and when the combination of entrepreneurial resources and entrepreneurial counseling is available, entrepreneurial performance can be yielded. However, the entrepreneurial environment or entrepreneurial counseling are not necessarily the only reason for the production of entrepreneurial performance.

Based on the analysis of entrepreneurial plans by researchers on entrepreneurial counseling, most entrepreneurs lack enough understanding of the entrepreneurial business model and are over-optimistic for the market. In particular, when technology, products, management, and finance are not professional enough, unsatisfactory entrepreneurial performance will be generated. One-to-one entrepreneurial counseling services with entrepreneurs are conducted to assist with the diagnosis of the business model for a new business and to enhance the insights of entrepreneurs into the market and entrepreneurial skills to enhance the quality and success ratio of entrepreneurs. In the entrepreneurial process, if the resources possessed by entrepreneurs are not enough, the failure ratio of entrepreneurs will be relatively high. Therefore, the results of fs/QCA could support the previous entrepreneurial counseling experience by researchers.

CONCLUSIONS

Regression analysis and fs/QCA are built on two different logics. Fs/QCA uses set theory to evaluate necessary or sufficient configurations of conditions that lead to an outcome. Regression analysis statistically evaluates the impact of an independent variable on a dependent variable. Fs/QCA hypotheses test for necessary conditions and sufficient combinations of conditions, the regression hypotheses focus on the average effect of individual variables or interactions (Vis, 2012).

In a regression analysis, such this outcome would amount to a no significant finding. However,

a low correlation between variables does not preclude the existence of relationships of necessity and/or sufficiency.

Since such an fs/QCA analysis still aims to understand how outcomes come about, namely, wants to account for the effect the approach remains more "qualitative" than "quantitative. Fs/QCA and regression differ in how they tackle limited diversity namely, the situation that not all possible combinations of conditions and outcome occur in reality (Ragin 2008). In a regression analysis, if an outcome (dependent variable) occurs and the given cause (independent variable) does not, it counts as negative evidence for the strength of that causal relationship (Epstein et al. 2008). This means that a factor that influences the outcome in only a subset of cases—but some cases nonetheless—becomes invisible in a regression analysis; in fact, it only inflates the variance and deflates the coefficients (Vis, 2012). By formalizing the logic of qualitative analysis, QCA makes it possible to bring the logic and empirical intensity of qualitative approaches to studies that embrace more than a handful of cases research situations that normally call for the use of variable-oriented, quantitative methods (Vis, 2012).

This study's conclusions have more rich implications, and classification means in reference to future researches. This paper fills the gap from previous studies and the results of this study will be helpful for subsequent scholars to conduct deep researches that exploring sufficiency conditions for entrepreneurial resources and counseling activities on entrepreneurial performance. As researchers, are more modest in our interpretation of the results. It is probably not a good idea to stringently adhere to any significance level when interpreting any output (Stockemer, 2013).

REFERENCES

1. Barney, J. B., (1991). Firm resources and sustained competitive advantage. Journal of Management, 17(1), 99-120
2. Chang, C. W., Tseng, T. H., & Woodside, A. G. (2013). Configural algorithms of patient satisfaction, participation in diagnostics, and treatment decisions' influences on hospital loyalty. Journal of Services Marketing, 27(2), 91-103.
3. Chrisman, J. J., McMullan, W. E., Ring, J. K., & Holt, D. T. (2012). Counseling assistance, entrepreneurship education, and new venture performance. Journal of Entrepreneurship and Public Policy, 1(1), 63-83.
4. Cross, B., & Travaglione, A., (2003). The untold story: is the entrepreneur of the 21st century defined by emotional intelligence?. International Journal of Organizational Analysis, 11(3), 221-228.
5. Dana, L. P. (1987). Entrepreneurship and venture creation: An international comparison of five Commonwealth Nations. Frontiers of Entrepreneurship Research. Ed. NC Churchill, JA Hornaday, BA Kirchhoff, OJ Krasner, and KH Vesper. Wellesley, MA: Babson College, 573-

583.

6. Dana, L. P. (1990). Saint Martin/Sint Maarten: a case study of the effects of culture on economic development. Journal of Small Business Management, 28(4), 91-98.

7. Devi, S. C.,(2011). A Study on the role of Government The focus on growth of women entrepreneur in small scale sector., International Journal of Exclusive Management Research June 1(2).

8. Dollingers, M. J.,(2003). Entrepreneurship: Strategies and Resources(3ed.).NJ: Prentice Hall International Inc.

9. Epstein, A. E., DiMarco, J. P., Ellenbogen, K. A., Estes, N. M., Freedman, R. A., Gettes, L. S., ... & Sweeney, M. O. (2008). ACC/AHA/HRS 2008 Guidelines for Device-Based Therapy of Cardiac Rhythm AbnormalitiesA Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to Revise the ACC/AHA/NASPE 2002 Guideline Update for Implantation of Cardiac Pacemakers and Antiarrhythmia Devices) Developed in Collaboration With the American Association for Thoracic Surgery and Society of Thoracic Surgeons. Journal of the American College of Cardiology, 51(21), e1-e62.

10. Fischer, E. M., Reuber, A. R., & Dyke, L. S. (1993). A theoretical overview and extension of research on sex, gender, and entrepreneurship. Journal of Business Venturing, 8(2), 151-168.

11. Fischer, E., & Reuber, A. R. (2003). Support for Rapid-Growth Firms: A Comparison of the Views of Founders, Government Policymakers, and Private Sector Resource Providers. Journal of small business management, 41(4), 346-365.

12. Fogel, G. (2001). An analysis of entrepreneurial environment and enterprise development in Hungary. Journal of Small Business Management, 39(1), 103-109.

13. Grant, R. M. (1991), "The resource-based theory of competitive advantage: implications for strategy formulation,," California Management Review, 33(3), 567-586.

14. Gourova, E. L. I. S. S. A. V. E. T. A., Todorova, Y. A. N. K. A., & Gourov, N. I. K. O. L. A. Y. (2009). Skills for future engineers: challenges for universities in Bulgaria'. WSEAS Transactions on Business and Economics, 6(7), 385-399.

15. Guo Zhenchang., (2003).Youth Unemployment and Employment Prospects,Community Development Journal 103.

16. Karunanithy, K., & Jeyaraman, S. (2013). Impact of Entrepreneurial Characteristics on the Organizational Development of the Small Business Entrepreneurs. Industrial Engineering Letters, 3(6), 28-33

17. Kent, R.,(2008). Empirical Approaches in the use of Fuzzy Set Analysis. Working Paper. Department of Marketing, University of Stirling,1-15.

18. Kevin C. Wootena, Thomas A. Timmermanb, Robert Folgerc ,(1999) The Use of Personality and the Five-Factor Model to Predict New Business Ventures: From Outplacement to Start-up , Journal of Vocational Behavior Volume 54, Issue 1, February 1999, Pages 82–101.

19. Koole, K., & Vis, B. (2010). Working Mothers and the State: How to Explain the Cross-

Government Variation in Maternal Employment Supporting Policies. In 8th ESPAnet Conference Budapest.

20. Kralj, D. A. V. O. R. I. N., & Markič, M. (2008). Sustainable development strategy and product responsibility. WSEAS Transactions on Environment and Development, 4(2), 109-118.

21. Lichtenstein, B. M., & Brush, C. G. (2001). How do "Resource Bundles" Develop and Change in New Ventures? A Dynamic Model and Longitudinal Exploration. Entrepreneurship Theory and Practice. 26(3),37-58.

22. Lundström, A., Almerud, M., & Stevenson, L. (2008). Entrepreneurship and Innovation Policies. Analyzing measures in European countries, FSF 2008:3.

23. Lu Chenxiang & Liangling Jing., (2008). Study of Female Entrepreneurship and Microfinance Mechanism，Graduate school of cooperative economics major：master of business administration.

24. Mark A. Ciavarellaa, Ann K. Buchholtzb, Christine M. Riordanb, Robert D. Gatewoodb, Garnett S. Stokesc(2004). The Big Five and venture survival: Is there a linkage?, Journal of Business Venturing 19 , 465–483.

25. Mello, P. A. (2012). A Critical Review of Applications in Qca and Fuzzy-Set Analysis and a'Toolbox'of Proven Solutions to Frequently Encountered Problems. In APSA 2012 Annual Meeting Paper.

26. Mocanu, A. M., Litan, D., Olaru, S., & Munteanu, A. (2010). Information systems in the knowledge based economy. WSEAS Transactions on Business and Economics, 7(1), 11-21.

27. Nagesh, P., & Murthy, M. N. (2008). The Effectiveness of Women Entrepreneurship Training Program: A Case Study. The ICFAI University Journals of Entrepreneurship Development.

28. O'Connor, S. M. (2007). Teaching IP from an Entrepreneurial Counseling and Transactional Perspective. . Louis ULJ, 52, 877.

29. Ragin, C. C. (2008). Redesigning social inquiry: Fuzzy sets and beyond. Chicago: University of Chicago Press.

30. Saunders, J. B., Aasland, O. G., Babor, T. F., & Grant, M. (1993). Development of the alcohol use disorders identification test (AUDIT): WHO collaborative project on early detection of persons with harmful alcohol consumption-II. Addiction, 88(6), 791-804.

31. Sharma, D. S., Verma, V., & Kumar, D. S. (2012). A Review: Women Entrepreneurship "An era of transition". International Journal in Multidisciplinary and Academic Research (SSIJMAR), 1(3), 1-12.

32. Stockemer, D. (2013). Fuzzy Set or Fuzzy Logic? Comparing the Value of Qualitative Comparative Analysis (fs/QCA) Versus Regression Analysis for the Study of Women's Legislative Representation. European Political Science, 12(1), 86-101.

33. Srivastava, R. K., Shervani, T. A., & Fahey, L. (1998). Market-based assets and shareholder value: a framework for analysis. The Journal of Marketing, 2-18.

34. Taticchi, Paolo, Tonelli, F., Hernandez, E., & Cagnazzo, L. (2009). Implementation of a Knowledge Management Tool within a VDO Network: Preliminary Results. WSEAS Transactions on Business and E conomics, 6, 2.

35. Vis, B. (2012). The comparative advantages of fs/QCA and regression analysis for moderately large-N analyses. Sociological Methods & Research, 41(1), 168-198.

36. Wang, C. K., (2009). A Study of Entrepreneurship Management in University (Doctoral dissertation).

37. Woodside, A. G. (2010). Case study research: Theory, methods, practice. Bingley, UK: Emerald Group Publishing.

38. Woodside, A.G. (2011), Responding to the severe limitations of cross-sectional surveys: commenting on Rong and Wilkinson's perspectives. Australasian Marketing Journal, 19, 153-6.

39. Woodside, A. G., Ko, E., & Huan, T. C. T. (2012). The new logic in building isomorphic theory of management decision realities. Management Decision, 50(5), 765-777.

40. Woodside, A. G., Schpektor, A., & Xia, X. (2013). Triple Sense-Making of Findings from Marketing Experiments Using the Dominant Variable Based-Logic, Case-Based Logic, and Isomorphic Modeling. International Journal of Business and Economics, 12(2), 131-153.

41. Woodside, A. G. (2013). How Algorithms with Happiness-at-Work Identify High (Low) Performing Hospitality Frontline-Employees: Transcending Variable and Cases-Based Analyses.

42. Wu, W. W. (2009). A competency-based model for the success of an entrepreneurial start-up. WSEAS Transactions on Business and Economics, 6(6), 279-291.

43. [43]Zhao, H., Seibert, S. E., & Lumpkin, G. T. (2010). The relationship of personality to entrepreneurial intentions and performance: A meta-analytic review. Journal of Management, 36(2), 381-404.

CAN THE HYBRIDIZATION OR LOCALIZATION HRM PRACTICES OF JAPANESE SUBSIDIARIES IN MALAYSIA BE A NEW SOURCE OF INSPIRATION FOR JAPANESE FIRMS IN JAPAN?

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ABSTRACT

Purpose: *With the prolonged economy downturn in the early 1990s and the recent global economy crisis in 2008, Japanese HRM practices have lost its appeal among Japanese organizations in Japan. The American HRM model instead has been viewed as their next source of inspiration due to its flexibility to create competitive advantages. However, the question remains whether Japanese organization can actually adopt to the American HRM approaches due to the cultural differences between Japan and America. The research attempt to understand if the unique hybridization or localization model adopted by most of the Japanese subsidiaries in emerging markets like Malaysia can also be a source of inspiration for Japanese organizations operating in Japan in this turbulence time. By understanding the viewpoints and perspectives of local employees of whether the HRM practices adopted by the Japanese subsidiaries in Malaysia can lead to better job satisfaction, the research eventual goal is to draw a recommendation on which HRM practices might be useful or something worthy learning for Japanese organizations operating in Japan.*

Design/methodology: *Many studies that attempted to study job satisfaction of different Japanese HRM practices focused on the macro perspective through quantitative study. Thus, they may not reflect the true picture of satisfaction of the employee. Since there are not many studies that*

attempt to study satisfaction from the perspective and viewpoint of respondents, this study attempts to adopt the qualitative approach via personal interview and participation observation. The study focused on one Japanese subsidiary operating in the state of Perak, Malaysia.

Findings: *Apart from staffing practices, other aspect of HRM policies and practices were suggested to be modified to improve competitiveness.*

Research Implications: *The study provides explanation and improvement on the HRM practices of other Japanese organizations operating in other developing markets like China, Indonesia, Thailand, and etc. In addition, by understanding the needs and motivations of the employees in Malaysia, the study serves as a learning curve and improvement in their future operations practices.*

Originality: *The study attempts to be the first to investigate on the hybridization and localisation issues as a source of inspiration from an emerging marker perspective.*

Keywords: Japanese Human Resource Management, hybridization, localization, Malaysia.

Classification: Case study

INTRODUCTION

The extraordinary growth of Japanese economy in the 1970s and the early 1980s was pointed to the uniqueness of Japanese-style Human Resource Management (HRM) which is based on the principles of equality, groupism, and community (Ishida, 1986; Amante, 1993; Jenkins and Florida, 1999). Oliver and Wilkinson (1992) has illustrated how Japanese manufacturers through this unique HRM practices achieved more than 50 percent of the global market in calculators, microwave ovens, color televisions, cameras and video recorders. The "three sacred treasures" which is the enterprise-based union (kigyobetsu rodo kumiai shugi), seniority systems wages and promotion (nenko joretsu) and lifetime employment system (shushin koyo) are mostly associated with the Japanese-style HRM practices (Masabumi, 2005). The combination of the "three sacred treasures" of the HRM practices has led to a stronger employee identification which resulted to increased productivity and low turnover rates for the Japanese organizations (Moore, 1987). However, with the prolonged economy downturn in Japan from the early 1990s to the recent global economy crisis in 2008 (Benson and Debroux, 2004; Maanen, 2006; Stiles, 2009), the Japanese HRM has lost its appeal and no longer viewed as a role model for Japanese organizations to emulate in Japan. The Japanese HRM is even regarded as outdated (Ornatowski, 1998, Pudelko 2009) and no longer viewed as important in today's challenging world (Crawford, 1998; Pudelko 2005). In the current challenging times, interestingly Japanese organizations have

shifted to the American HRM as their source of inspiration (Pudelko, 2004; Kodama, 2009). Using Japanese organizations as examples, Chaudhuri (2010) provides empirical evidences that the HRM practices of Japanese organizations in Japan are indeed moving towards the American HRM practices. Similar evidence was found in Malaysia, whereby the recruitment practices are leaning towards the American HRM model (Tan et al., 2012b). American HRM has been viewed positively due to its flexibility to create competitive advantages. However, the question remains whether Japanese organization can actually adopt to the American HRM approaches due to the cultural differences between Japan and America. Japan is traditionally a collectivist society which stresses on harmony and teamwork contradicting with the individualistic American culture which emphasize on the evaluation of individual performance (Hosftede, 1997). In view of the contradicting practices, the adoption of American HRM in Japanese organization in Japan may not bring an improvement in job satisfaction among employees. On the contrary, it may even lead to a decline of performance and lower organizations' commitment. Hence, the question again remains whether American HRM is the best model to adopt in view of the differences in the institutional and cultural factors in Japan. Tan et al (2012a) in their research on Malaysia Japanese firms provide evidences that some of the HRM practices resemble the local and hybridization practices. The literature reviews of Japanese organizations adopting to American HRM as a source of inspiration in this turbulence time has lead us to trying to understand if the unique hybridization or localization model adopted by most of the Japanese subsidiaries in emerging markets like Malaysia can also be a source of inspiration for Japanese organizations operating in Japan. Pudelko (2009), concluded that many Japanese organizations operating in Japan often regard their foreign subsidiaries as a 'learning laboratories' to experiment with different HRM practices before implementing the best practices in their headquarter. If so, is there really something worthy to learn from their subsidiaries overseas? If yes, what and which particular of the HRM aspects? By understanding the viewpoints and perspectives of local employees of whether the HRM practices adopted by the Japanese subsidiaries in Malaysia can lead to better job satisfaction, the research eventual goal is to recommend and draw a conclusion of which HRM practices might be useful or something worthy learning for Japanese organizations operating in Japan. Although many studies have been done on the transfer of Japanese style HRM practices to their subsidiaries abroad (Dedoussis, 1995; Roger and Wong, 1998; Jenkins and Florida,1999; Raduan and Kumar, 2007), many scholars did not attempt to study whether this practices implemented by their parent company has actually lead to job satisfaction among the local employees here. Even if they were, most studies have attempted to study the satisfaction at the macro view (Colignon, et al., 2007; Mohani, Ismail and Jaafar, 2010) such as through quantitative study. Thus, previous study may not have reflected the real picture necessary to explain on the employee's job satisfaction. Secondly, while there are many empirical studies relating to the uniqueness of Japanese and American style HRM as the secret of success (Ouchi, 1981; Fukuda, 1988; Jenkins and Florida, 1999; Masabumi, 2005; Pudelko 2009), there seems to be a serious omission related to whether the hybridization or localization

practices of Japanese organizations in Malaysia can result to something beneficial for Japanese organizations operating in Japan. This little empirical work is puzzling as Japan has been regarded as one of the major investors around the world, and thus without the view of cross-national adoptions, the practical and manager's knowledge of Japanese management is incomplete. In both of the situations the research attempts to be the first to explore on the above issues. For this reason, Malaysia is an ideal place to study on the theory for at least a few reasons. Firstly, Japanese organizations are one of the largest investors in Malaysia with a total of 18.5 percent firms out of the more than 3000 multinationals enterprises operating in Malaysia (Sambasivan and Jacob, 2008). The investment in 2007 was estimated to be at RM47.2 billion with manufacturing sector consisting of 2,215 projects (MITI,2008). In view that the job satisfaction helps to predict employee's retention and work performance, the results from this finding will be beneficial to all of Japanese multinationals operating in Malaysia. Secondly, Malaysia is composed of diverse employees with different religions, races and cultures (Foong and Richardson, 2007). Although so, Malaysian shares common values such as concern for-face saving, emphasis on relationships, collective orientation, respect for the elderly and religious orientation (Selvarajah and Meyer, 2008) which is similar like in Japan. Moreover although the HRM practices of the Japanese subsidiaries in Malaysia are regarded as unique by its own, it still has a strong distinctively Japanese flavor. Scholars like Raduan and Kumar (2007) and Tan et al (2012a) again provided evidences that the HRM practices of Japanese subsidiaries in Malaysia contain some Japanese elements. Hence, we believe that any attempts to transfer the practices out to Japan will make more sense, especially if the practice is originated from Malaysia.

LITERATURE REVIEW

Dedoussis (1995) commented that since HRM has been identified as the source of the Japanese's competitive advantages, many Japanese organizations often transfer their practices to their subsidiaries abroad (Roger and Wong, 1998). However, many Japanese organizations do not transfer their full spectrum of the Japanese HRM practices to their local affiliates overseas as they need to accommodate to the local conditions of the host country, which are bounded by the institutional or social cultural factors (Dore, 1973; Fukada 1988; Brewster 1995; Rosenzweig and Singh 1991; Jackson and Schuler 1995). As a result, the HRM practices of the local Japanese subsidiaries in the host country may resemble the local practices or resembles the hybridization model which neither follow the country-of-origin's practice nor country-of-destination's practice (Negandhi et al., 1987; Florian and Becker-Ritterspach, 2005). Raduan and Kumar (2007) using 69 Japanese subsidiaries in Malaysia found that most HRM practices have not been transferred in the original model and thus they resemble the localization practices. Similarly, Mohani, Ismail and Jaafar (2010) using Malaysian executives employed in Japanese electrical and electronic manufacturing companies found that 35.1 percent of the employees were highly satisfied, 31.8 percent were moderately satisfied and only 33.1% are dissatisfied. Along the same findings, a

HRM researcher in Malaysia provide empirical evidences that some of the HRM practices of Japanese subsidiaries in Malaysia resembles the hybridization model while some remains localized due to cost and economic considerations (Tan et al., 2012a).

RESEARCH METHOLOGY

This research paper investigates if the HRM practices among the Japanese subsidiary in Malaysia which are hybrid or localized in nature can bring to better job satisfaction among the employees in Malaysia. Specifically, by understanding which HRM practices can bring higher satisfaction in job performance, the research subsequently goal is to identify a certain HRM pattern for Japanese organizations in Japan to adopt as a learning lesson or recommendation as a new source of competitive advantages. Although there are many studies that attempted to study job satisfaction of different Japanese HRM practices, but most of the research mainly focused on the macro perspective through quantitative study. Hence, they may not reflect the true picture of satisfaction of the employee. Since there are not many studies that attempt to study satisfaction from the perspective and viewpoint of respondents, this study attempts to adopt the qualitative approach as the method provide answers to the questions relating with 'how' and 'why' (Yin, 1994). A case study method with qualitative interview, participation observation and collection of secondary data from subsidiary will be adopted in this study. Yin (1994 p. 92) concluded that multiple techniques "allow an investigator to address a broader range of historical, attitudinal, and behavioral issues". This study deliberately focused on one Japanese subsidiary operating in the state of Perak, Malaysia and was randomly drawn using the directory published by Japan External Trade Organization Kuala Lumpur (JETRO KL). This region was chosen in view that it has received large foreign direct investments from Japan in the last decade. The subsidiary of the case study produces wooden component parts and has been established in Malaysia since 1994 with presence all over South East Asia. The subsidiary currently employs about 600 employees. The interview questions were based on HRM themes such as staffing practices, recruitment, welfare system and concern, promotion system, career path, and training and development (Tan et al., 2012a). In comparison, the qualitative interview approach emphasizes on the voices and mood of the respondents on the challenges, dilemmas, judgments and viewpoint of the HRM practices. The research interviewed three employees (the HR manager, a senior executive (employee A) and junior executive (employee B)) from the subsidiary of study between July to December 2013 which lasted about 3-4 hours depending on the background and flow of conversation. Those selected will be those having the best experience and insights to whether the HRM practices adopted by the organization can lead to better job satisfaction. Their viewpoint is critical in understanding the complexity of the HRM adoptions, which the subsequent objective will ultimately rely upon.

FINDINGS

Employment Policies and Practices: Staffing Practices

The HR manager indicated that the retirement age follows the regulation sets by the Malaysia's government whereby it is 55 years for male and female respectively. This is also similar with the local practices for other blue and white collar employees. In addition, employees are allowed to continue to work based on 30 percent salary deduction and 1 year contract basis after retirement. In terms of unsatisfactory work performance, unless it is related to serious misconduct e.g, stealing, sexual harassment, and etc., employees are given ample of opportunities and counseling to improve themselves. Show cause letter and termination will only be given at last resort. On the layoff policy, first they will reduce the working hours. This is proceed by reassigning tasks/jobs and even a transfer to their other subsidiaries. Voluntary Separate Scheme (VSS) is only at the last resort. According to the interview given by employee B, working in Japanese organizations provide high level of job security and comfort as they allows employees to further improve themselves if they underperform. In addition, job training is also provided if employees are unable to cope with their tasks. Employee A commented that the continuance of employment after retirement is ideal as the elder employees can help to transfer knowledge to younger employees and also to provide continues mentoring.

Employment Policies and Practices: Recruitment

Based on the interview with the HR manager, the recruitment is based on ad-hoc and depends on projects. There is no indication that the subsidiary prefers to recruit employees from top university in Malaysia. Inexperienced white collar employees are given more preference than experience employees. Similarly, inexperience workers are also given much preference for blue collar category as most tasks are automated and thus do not require much skills. The HR manager also indicates that they prefer to hire Myanmar/Bangladeshi nationalities for production works as they are able to pick up the Malay language fast and are less trouble makers when compared to Vietnam workers. The HR manager also stressed that behavioral aspect is given upmost priority prior to hiring. The subsidiary will normally call the referee or their previous organization to know about their behavior. The decision to hire is made by the managing director and human resource manager. Interestingly, the organization has stopped hiring permanent staff. All employees from 2006 onwards are hired based on contract basis depending on the job nature. Blue collar employees for example are hired on one year contract since their job is based on ad-hoc projects. According to the interview given by employee A, the selection of the organization to hire inexperience workers is part of their strategy to reduce cost. Moreover with proper job training and the number of elderly employees available, the new employee should be able to pick up the job fast. Employee B however added that at times, hiring inexperience employee brings more workload for experienced employees as they are tasked to mentor on their performance. The employee also further hopes that the subsidiary would proceed to hire based on permanent

basis and not contractual.

Remuneration systems: Welfare System

According to the HR manager, the welfare system resembles the Japanese traditional HRM practices whereby the bonus payment which is once per year is similar across different ranks of employees regardless of their performance. In addition, the benefits and allowances are similar for both white and blue collar employees (e.g, meal, travelling, housing allowances). However additional allowances will be given if the employee is at the managerial level. Based on the feedback given by employee A, he hopes that the organization will move away with the current system as it does not promote competitiveness and can be a major frustration for hardworking and ambitious employees. Similar sentiment was shared by employee B.

Remuneration systems: Promotion System

Based on the HR manager, the promotion system is still depends on the seniority system whereby the promotion is based on the length of employment for both collar of employees. In addition, annual appraisal (e.g, management by objectives (MBO)) is done with no clear purpose apart from formality once a year for white collar employees. For blue collar employees however, the MBO system is one yearly in view of their work nature which is measured by production outputs. Behavioral aspect is also given heavy weightage for both categories of employees. The company has also policy not to hire any external party for management level and would prefer to fill in the position from within. Based on the feedback given by employee B, the promotion system is very discouraging for young employees. However employee A added that the system is much preferred by older employees as they will be promoted based on their years of service and not on merit. In addition, employee B added that the system is unfair as EQ (e.g, behavior) is given more preference than IQ for promotion system and hopes that MBO should be taken more seriously.

Career Development Practices: Career Path

While acknowledging that some Japanese organizations in Malaysia rotate their employee to various departments, the HR manager indicated that their career path differs. Job rotation is only applied within the same functions and not cross department for white-collar employees. Blue collar employees however are involved with job rotations. In addition, each employee is expected to multitask whereby they could be involved with tasks beyond their core competencies e.g, the accounting manager is also expected to know human resources. There is also not indication of special career track for fast achievers. Employee A said that while the job rotation within different sections are encouraging, multitasking different work competencies is not an easy task and thus may affect the moral of employees.

Career Development Practices: Training and Development

In view of the Human resource development fund (HRD) in Malaysia, training and development has been decentralized from production to HR department for both blue and white collar employees, according to the HR manager. Training needs are geared towards job requirement and the needs of the organziations and not based on preference or talent. On the number of training days, the numbers are similar for both white and blue collar employees for perquisite training e.g, orientation, health and occupational safety, and etc. Moreover employees are encouraged to attend basic Japanese classes conducted by Federal Malaysian Manufacturers (FMM). Teambuilding and understanding Japanese culture is also compulsory. According to employee B, while the organization is generous in terms of numbers of trainings days and the amount spend, the selection of training course is based on the job scope and not on individual's preference. She quoted for example training courses such as communication skills, computer skills, leadership skills which relates to individual's improvement are not given any preference. Employee A on the other hand hopes that there will be more opportunities for employee to be selected for training in Japan in future.

IMPLICATIONS AND CONCLUSION

This research paper investigates if the HRM practices among the Japanese subsidiary in Malaysia which are hybrid or localized in nature can lead to better job satisfaction among the employees in Malaysia. Based on the selected HRM practices, employees hope that the welfare system will be based on merits, MBO is taken more seriously, less emphasis on multitasking work, training which focuses on individual improvement and hiring on permanent basis rather than contracts. The suggestion should be taken into consideration to further improve on the satisfaction of employees. The finding is similar with a research conducted by Foong and Richardson, (2007) in Malaysia whereby the employees from the Japanese subsidiary are not satisfied with the promotion, training, benefits and welfare listed by the subsidiary. Mohani, Ismail and Jaafar (2010) also recommended that the merit based system to be introduced in the promotion and salary system to promote competitiveness. This study aims to contribute in several aspects on HRM practices for Japanese organizations both in its' emerging markets and those operating in Japan. In terms of the theoretical implications, the study is the first to explore whether the HRM practices of Japanese subsidiary in Malaysia which are hybrid and localize in nature can result to something beneficial for Japanese organizations. Thus this adds varieties to the debate of country-of-origin and host country debates which are currently a debatable topic among international HR academicians. From the managerial implications, firstly, the findings help to understand the key drivers to job satisfaction among local employees of the Japanese subsidiaries in Malaysia. By understanding the employee's frustration and their motivation factor, Japanese organizations can further improve on those practices which may lead to better competitive advantages and organization commitment. Secondly, by shedding lights on the

outcomes of the satisfaction or dissatisfaction of the HRM practices, the study helps to recommend which HRM practices that might come in useful for Japanese organizations operating in Japan to emulate. Thus, the study helps to provide an alternative to the Japanese organizations other than the sole American HRM approaches.. Lastly, the results can also help to explain or improve the HRM practices of other Japanese organizations operating in other emerging markets like China, Indonesia, Thailand and etc. By understanding the needs and motivations of the employees in Malaysia, the study serves as a learning curve and improvement in their future operations practices.

FUTURE RESEARCH

The study adopted a case study method using only one single Japanese subsidiary in Malaysia from the woodwork industry. Thus the biggest limitation is the sample size which we cannot use to generalize the HRM findings of other Japanese related organizations in Malaysia. To overcome this limitation, future research may increase the sample size ranging from different industries. Finally, the study adopted a qualitative method which provides opportunity for interviews to express their thoughts. While this may be useful to achieve our research objective, they may not provide a realistic view since some HRM practices may have greater impact than others. Hence future researchers could adopt the quantitative method to provide greater insights on the employee job satisfaction.

ACKNOWLEDGEMENT

REFERENCES

1. Amante, M.S.V. (1993), "Human resource management in Japanese enterprises in the Philippines:issues and problems", Asia Pacific Journal of Management, Vol. 10, No. 2, pp. 237-245.
2. Benson, J. and Debroux, P. (2004), "The Changing Nature of Japanese Human Resource Management The Impact of the Recession and the Asian Financial Crisis", International Studies of Management and Organization, Vol. 34 No.1, pp 32-51.
3. Brewster, C. (1995), "Towards an 'European' model of human resource management", Journal of International Business StudieS, Vol. 26, No. 1, pp.1-21.
4. Chaudhuri, K. (2010), "Exploring employee consciousness of HWPS and commitment in Japanese organizations: An empirical approach", Journal of International Business Disciplines, Vol. 5 No.1.

5. Colignon, R.A., Usui, C., Kerbo, H.R., and Slagter, R. (2007), "Employee Commitment in U.S. and Japanese Firms in Thailand: The perceptions of Malaysians in a Japanese company", Asian Social Science, Vol. 3, No. 11.

6. Crawford, R.J. (1998), "Reinterpreting the Japanese Economic Miracle", Cambridge, MA: Harvard University Press.

7. Dedoussis, V. (1987), "Management systems and practices in Japanese subsidiaries: Japanization or localization?", Asia Pacific Journal of Human Resources, Vol. 25, No. 1, pp.42-54.

8. Dedoussis, V. (1995), "Simply a question of cultural barriers? The search for new perspectives in the transfer of Japanese management practices", Journal of Management Studies, Vol. 32 No. 6, pp.731-745.

9. Dore, R. (1973), "British Factory, Japanese Factory: The Origins of National Diversity in Industrial Relations", University of California Press, Berkely, CA.

10. Florian, A.A., and Becker-Ritterspach, F. (2005), "Transfer, intercultural friction and hybridization: empirical evidence from a German automobile subsidiary in India", Asian Business & Management, Vol. 4 No. 4, pp.365-387.

11. Foong, Y.P., and Richardson, S. (2008), "The perception of Malaysians in a Japanese company", Cross Cultural Management: An International Journal, Vol. 15 No. 3 pp. 221-243.

12. Fukuda, J. (1988), Japanese-Style Management Transferred: The Experience of East Asia, Routledge, London.

13. Hofstede, G. (1997). Cultures and organizations: software of the mind. London: Mc Graw Hill.

14. Ishida, H. (1986), "Transferability of Japanese human resource management abroad", Human Resource Management, Vol. 25 No. 1, pp.103-120.

15. Jackson, S.E., and Schuler, R.S. (1995), "Understanding human resource management in the context of organizations and their environments", Annual Review of Psychology, Vol. 46 No. 1, pp.237-264.

16. Japan External Trade Organization (JETRO) Kuala Lumpur, accessed on 20 May 2013 http://www.jetro.go.jp/malaysia/about/

17. Jenkins, D., and Florida, R. (1999), "Work System Innovation among Japanese Transplants in the United States", in Paul et al. (Eds.). Remade in America: Japanese Transplants and the Diffusion of Japanese Production Systems, New York: Oxford University Press.

18. Maanen, J.V. (2006), "Rediscovering Japan: some thoughts on change and continuity in traditional Japanese careers", Career Development International, Vol. 11No. 4, pp. 280-292.

19. Masabumi, T. (2005), "The shift towards American-style human resource management systems and the transformation of workers' attitudes at Japanese firms", Asian Business & Management, Vol. 4 No. 1, pp.23-44.

20. MITI (2008), available on-line at http://www.miti.gov.my on 3 July 2013

21. Kodama, M. (2009), "Boundaries Innovation and Knowledge Integration in the Japanese Firm", Long Range Planning, Vol. 42 No.4, pp.463-494.

22. Mohani A., Ismail, H., and Ismail, N.H.J. (2010), "Job Satisfaction Among Executives: Case of Japanese Electrical and Electronic Manufacturing Companies, Malaysia", The Journal of Global Business Management, Vol. 6 No. 2, pp. 165-173.

23. Negandhi, A.R., Eshgi, G.S., and Yuen, E.C. (1985), "The management practices of Japanese subsidiaries overseas", California Management Review, Vol. 27 No. 4, pp. 93-105.

24. Oliver, N., and Wilkinson, B. (1992), The Japanization of British Industry: New Developments in the 1990s. London: Heinemann.

25. Ornatowski, G. (1998), "The end of Japanese-style human resource management", Sloan Management Review, Vol. 39 No. 3, pp. 73-84.

26. Ouchi, W.G. (1981), Theory Z, Avon, New York.

27. Pudelko, M. (2005), "Cross-National Learning from Best Practice and the Convergence-Divergence Debate in HRM", International Journal of Human Resource Management, Vol. 16 No. 11, pp. 2047-2076.

28. Pudelko, M. (2004), "HRM in Japan and the West: What are the Lessons to Be Learnt from Each Other?", Asian Business and Management, Vol. 3, pp. 337-361.

29. Pudelko, M. (2009), "The End of Japanese-Style Management", Long Range Planning, Vol. 42, pp. 439-462.

30. Roger, G., and Wong, A. (1998), "The cross-cultural transfer of management practices: the case of Japanese human resource management practices in Singapore", The International Journal of Human Resource Management, Vol. 9 No. 1, pp.116-135.

31. Rosenzweig, P.M., and Singh, J.V. (1991), "Organizational environments and the multinational enterprises", Academy of Management Review, Vol. 16 No. 2, pp. 340-361.

32. Sambasivan, M., and Jacob, G. (2008), "An Empirical Study on the Impact of Supply Chain Practices on Competitive Position of MNEs in Malaysia", International Journal of Economics and Management, Vol. 2 No. 2, pp. 369-394.

33. Selvarajah, C. and Meyer, D. (2008), "One nation, three cultures: exploring dimensions that relate to leadership in Malaysia", Leadership & Organization Development Journal, Vol. 29 No. 8,pp. 693-712

34. Stiles, P. (2009). The Changing Nature of the Japanese Business System and Its Impact on Asia, Long Range Planning, 42, 42-438.

35. Tan, G.W.H., Chua, B.H., Tan B.I., and Ooi, K.B. (2012a), "A case study on Japanese HRM practices in Malaysia: Japanisation or localization?" International Journal of Innovation and Learning, Vol. 12 No. 3, pp.332-35.

36. Tan, G.W.H., Tan, B.I., Ooi, K.B., and Ng. J.C.C. (2012b), "A Case Study on the Impact of Recession on the Recruitment Practices of Japanese Subsidiaries in Malaysia: Are They Converging to the Anglo-Saxon Model?", The 5th International Borneo Business

Conference (IBBC), December 19-21, Belmont Marco Polo Hotel, Tawau, Sabah, Malaysia.
37. Yin, R.K. (1984), Case Study Research: Design and Methods, Beverly Hills, Calif: Sage.

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KNOWLEDGE MANAGEMENT: A NEW MEASURE FOR COMPETITIVE ADVANTAGE?

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ABSTRACT

Purpose: This paper seeks to explore the tri-dimensional relationship between knowledge management (KM) approaches (i.e. knowledge acquisition, dissemination, and application), technological innovation and competitive advantage. At the same time, technological innovation as a mediating variable between KM and competitive advantage will also be determined.

Design/methodology/approach: A theoretical framework was proposed to investigate the relationship between KM, technological innovation and competitive advantage, with technological innovation being the mediating factor.

Findings: This research outlines how the KM approaches can be an effective coordinating mechanism to improve a firm's technological innovation and competitive advantage.

Research limitations/implications: Firms with KM will have the capability to use resources more effectively and efficiently, and so will be more innovative technologically, achieving a competitive edge over their competitors.

Originality/value: This conceptual model will provide further theoretical insight regarding the intertwined relationships among the three constructs as well as the mediating effect of technological innovation on the link between KM and competitive advantage.

Keywords: Knowledge Management, Technological Innovation, Competitive Advantage

Classification: Conceptual paper

INTRODUCTION

Knowledge management, also known as KM, has widely permeated the business world in recent years, as companies possessing the ability in creating, managing and applying the knowledge at hand have an advantage over the rest (McAdam and Leonard, 2001; Desouza and Evaristo, 2003; Rademakers, 2005). The underlying assumption that managing knowledge can bring a difference to an organization bottom line is the key rationale for such wide-spread KM presence in both managerial rhetoric and practice. It has also been concluded that an organization that learns is an organization that innovates (Therin, 2002; Hung et al., 2010). Innovation, according to a few researchers in the likes of Weerawardena et al. (2006) and Hung et al. (2010), is a company's intangible asset that is close to impossible to replicate, hence is recognized as a firm's vital capital to secure a sustainable competitive position in the business arena. Companies, in particularly those that are strongly dependent upon complicated technologies to compete globally are more exposed to the many challenges faced due to the rapid changes in technology. As such, it is vital for both practitioners and managers alike to conduct a research on the topic of KM and innovation, to ensure the sustainability of firms.

While past studies reported KM being the main antecedents of innovation (Nonaka and Takeuchi, 1995; Davenport and Prusak, 1998; Darroch and McNaughton, 2002; Hall and Andriani, 2003) and that innovation can lead to increased competitiveness (Weerawardena et al., 2006; Hung et al., 2010), there is still a lack of conceptual studies that has yet to examine the tri-dimensional relationship between the three main constructs of KM practices, technological innovation (TI) and competitive advantage (CA). Furthermore, the possibility of TI being the mediating variable between KM and CA has yet to be extensively researched. Hence, it is vital to study the interrelations between these three constructs and the possibility of TI being the mediator between each KM practice with CA.

This study purports to address such gaps, determining whether KM can enhance a firm's ability to innovate and achieve competitiveness; and whether TI serves as an effective mediator between KM practices and CA. Specifically, this research aimed:

(1) To explore the relationship between KM approaches (knowledge acquisition, knowledge dissemination, and knowledge application) on both TI (process and product innovation) and CA.

(2) To determine the importance of TI in achieving CA.

(3) To set focus on the mediating role of TI between KM and CA.

(4) To determine the tridimensional relationships between the three constructs of KM, TI and CA.

The paper has been structured as follows. The next section will begin with the introduction of the three important terms of this paper (i.e. KM, TI and CA), followed by a review of prior empirical literatures that support the development of the propositions for the conceptual framework formulated. Lastly, the paper will end with research implications from both managerial and theoretical perspectives as well as a general conclusion.

Knowledge management

Wang (2007, p.30) as cited in Chong et al. (2014) defined KM as "a process cycle to identify, transfer, store and disseminate the knowledge in order to reuse, awareness, and to share and learn it across the organization". Three main activities were identified in KM practices, i.e. knowledge acquisition, knowledge dissemination, and knowledge application, and are generally adopted by the researchers (Chong et al., 2014, Chen and Mohamed, 2006). These three areas are important measures in determining the successful implementation of KM practice in a firm. Knowledge acquisition is to locate, create or discover new information (Darroch, 2003). Knowledge dissemination, as described by Ng et al. (2012), is the ability to assess information conveniently among organizational members. Knowledge application is the ability to be responsive to the knowledge acquired, enabling information to be more effective to increase its worth, as defined by Ng et al. (2012).

Technological innovation

TI, in essence, relies on knowledge as a major force in societal change (Betz, 2011). According to him, the two basic issues about knowledge are creation and application of knowledge. While the former is the domain of science, the latter, i.e. knowledge application taps on the domain of technology. Scholarly research about firm's innovation performance can be categorized into multiple, dichotomous categories, i.e. radical/incremental, product/process, and technological/administrative innovation (Cooper, 1998; Damanpour, 1992). TI is a combination of product and process innovation, and is adopted by studies such as Lee et al. (2013) and Damanpour and Gopalakrishnan (2001). For the purpose of this conceptual paper, TI is emphasized instead due to that it contains the form of innovations (product and process) which enable the firms to "solve problems, improve performance, add value and develop the competitive advantage of a firm" (Cooper, 1998 as cited in Ng et al., 2012).

Competitive advantage

CA, as defined by Porter (1985) is a situation where a firm is capable to operate in a manner that is more efficient or at a higher quality as compared to its competitors, which will result in benefits accruing. Core competency is another term that can used to describe competitive advantage, in which it is defined as the one thing that a company can do better when compared to its competitors. CA can encompass a variety of company characteristics. For example, Rao and Holt (2005) manifested competitiveness in terms of four elements, which are (1) improved efficiency, (2) quality improvement, (3) productivity improvement and (4) cost savings. The dimensions used by Rao and Holt (2005) are similar to Porter's (1985) definition. In the heart of Porter (1985)'s definition of CA, two basic types of CA were identified, which are (1) lower cost and (2) differentiation. Lower cost is the firm's ability to design, manufacture and market a product that is more efficient than its competitors in terms of producing it at a lower cost; whereas differentiation is the firm's ability to provide buyers with a unique and superior value in terms of special features, product quality, or after-sale service.

PROPOSITION DEVELOPMENT

Knowledge management and technological innovation

A number of empirical studies have been found to support the positive correlation between knowledge acquisition and innovation (Lynn et al., 2000; Zhang et al., 2010; Tan and Nasurdin (2011). These studies have proven the effectiveness of knowledge acquisition on innovation performance. Meanwhile, researchers in the likes of Lin (2007), Liao et al. (2007), Scarbrough (2003) and Calantone et al. (2002) have proven the importance of knowledge sharing in enhancing a firm's innovation performance. Furthermore, positive connection between knowledge application and innovation was found in the studies of Darroch and McNaughton (2002), Lin and Lee (2005) and Madhoushi et al. (2011). KM practices in the form of acquisition, sharing, application, and storage were found to be empirically related with technological innovation in the context of manufacturing industries (Lee et al., 2013).

While most studies mentioned earlier are targeted at relationship between knowledge management and innovation performance, few have given a focus toward TI. According to Ng et al. (2012), it is proposed that the each KM facet, i.e. acquisition, dissemination, and application were found to be conceptually linked to technological innovation. Hence, a proposition is forwarded as such that the dimensions of KM will be positively related with TI. And due to that existence of KM precedes the happening of innovation in a company, it is conceptually proposed that KM will positively trigger and affect TI.

P1: Knowledge management positively affects technological innovation.

Knowledge management and competitive advantage

KM implementation will elevate firms at a better position in terms of CA in the market. For example, firm's CA can be manifested in the form of cost saving and product quality improvement when appropriate KM practices were applied (Akdere, 2009). Also, Earl (2001) in his taxonomy for KM highlighted that firms relying on KM is capable of business adaptation and renewal. This contributes to differentiation strategy and sustainability which lead to CA. Argote and Ingram (2000) mentioned that knowledge can be served as a basis of CA by making it hard to be imitated by the competitors.

P2: Knowledge management positively affects competitive advantage.

Technological innovation and competitive advantage

Castro et al. (2011) in a guest editorial about the knowledge-based view of firm innovation wrote:

> "…one of the best ways for reaching firm competitive advantage position comes directly from continuous technological innovations" (p. 872).

In fact, the idea that innovation promotes competitive advantage can be traced back to Porter (1980). As cited in Cooper (1998), he said:

> "Organizational theorists and managers alike have long shown more of an interest in the role of innovation in organizations, primarily because of the crucial role innovation plays in securing sustained competitive advantage" (p. 493).

CA can be in form of superior financial performance. Recent meta-analysis by Rubera and Kirca (2012) revealed that firm innovativeness has direct impact toward financial position and firm value. Gunday et al. (2011) in the study of the effect of innovations on firm performance in the context of Turkey manufacturing firms found that innovative performance in the form of organizational innovation, product innovation, and marketing innovation eventually lead to financial performance. Though neither of the studies above mentioned 'competitive advantage', it is believed that the firms that innovate put themselves in a better position and enjoy CA either in the form of improved efficiency, quality improvement, productivity improvement or cost savings (Rao and Holt, 2005).

P3: Technological innovation positively affects competitive advantage.

Knowledge management, technological innovation and competitive advantage

The dimensions of KM and TI were conceptually and empirically linked (Ng et al., 2012; Lee et al., 2013). Furthermore KM provides a ground for firm's CA by making knowledge hard to imitate by its competitors (Argote and Ingram, 2000), as well as better cost saving and product quality improvement (Akdere, 2009). Also, firm's TI leads to CA (Rubera and Kirca, 2012; Gunday et al., 2011). This tripartite relationship is initially explored by Carneiro (2000), whereby he conceptualized innovation and competitiveness as the function of KM. With recent research continuing to shed light to the importance of these relationships, we propose TI as the mediator between KM practices and firm's CA.

P4: Technological innovation mediates the relationship between knowledge management and competitive advantage.

It is important to realize that with the help of KM and innovation, the firms are in a better position to create sustainable success, i.e. CA over their competitors. This is done by continuously acquiring new and relevant knowledge, disseminating it effectively, and applied to current products or processes. Innovation emerges when new or improved product and service is created, which contributes to a firm's CA in the form of cost saving, quality improvement, efficiency, and productivity improvement.

Figure 1 illustrates the conceptual model of this research, in which the three-dimensional relationships between the constructs of KM, TI and CA will be investigated. First three propositions deal with individual relationship among KM, TI, and CA, while P4 proposes a relationship between KM and CA, with TI as mediator.
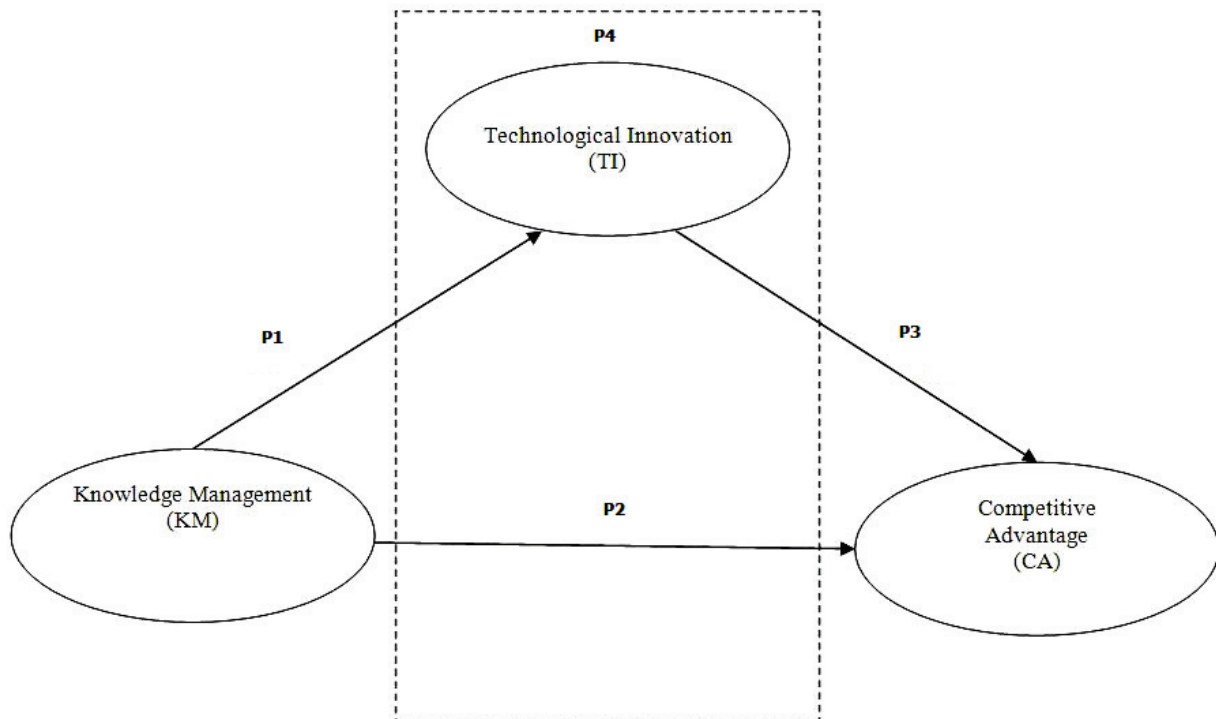
Figure 1

IMPLICATIONS

Theoretical implication

Very limited studies have been conducted in examining the impacts of KM on TI and CA. Carneiro (2000) has proposed a conceptual model with innovation and competitiveness as a function of KM. Nevertheless, in Carneiro's model, the influence of innovation towards CA was not explored. In this study, we have proposed a conceptual model which is more comprehensive in terms of examining the tridimensional relationships between KM, TI and CA. TI is theorized as the mediator variable which may influence the relationship between KM and CA. This revised conceptual model will provide further theoretical insight regarding the intertwined relationships among these entities as well as the mediating effect of TI on the link between KM and CA. The conceptual model may also serve as a theoretical framework for researchers to further verify the propositions theorized in this study using qualitative, quantitative or mixed method approach.

Managerial implication

The conceptual model is able to provide guidance and reference for managers, administrators and practitioners in a way that it gives a better conceptual understanding regarding the influence of

KM on TI and CA as well as the impact of TI on CA. Based on this conceptual model, all stakeholders will be able to allocate adequate attention, effort and resources to the right practices, in order to sustain competitive advantage in the business world.

Concisely, firms and companies need to put in effort to practice KM as it is the antecedent to TI and CA. Significant attention and focus are needed to ensure that knowledge acquisition is practiced in entrusting TI of products and processes. Furthermore, knowledge dissemination is also required as an alternative route to attain technological innovation. Besides that, knowledge application is also imperative to generate new ideas of more innovative products and processes. The emergence of these innovative products and processes will strengthen the CA of the firms and companies as they will be better able to compete in the open market. With proper emphasis being put in KM and TI, firms and companies will have the upper hand to achieve a sustainable CA in the long run.

CONCLUSION

As a conclusion, the proposed conceptual model has explicated the tridimensional relationships between KM, TI and CA. TI is theorized to have a mediating effect on the link between KM and CA. Until now there has been scarcity in research on the mediating effect of TI. Hence, this conceptual model will provide some conceptual guidance to managers, practitioners and all stakeholders of firms and companies in assessing the needs and attentions to be given to the respective components in the model. It is strongly believed that this conceptual model will help them to strengthen their CA and eventually contribute to the sustainability and growth of the firms and companies.

The conceptual model would be of great value to both practitioners and researchers if it is empirically tested, in order to quantify the strength of the relationships between KM, TI and CA; as well as the mediating effect of TI in the linkage between KM and CA. Among the batteries which can be operationalized for KM are Martinez-Costa and Jimenez-Jimenez (2009) and Perez et al. (2006) whereas for TI is Prajogo and Sohal (2003). Through the empirical findings, we may further quantify the strengths of the relationships as well as predicting the outcomes of the influence of KM and TI on CA.

ACKNOWLEDGEMENT

REFERENCES

1. Akdere, M. (2009), "The role of knowledge management in quality management practices: achieving performance excellence in organizations", *Advances in Developing Human Resources*, Vol. 11 No. 3, pp, 349-369.

2. Argote, L., and Ingram, P. (2000), "Knowledge transfer: a basis for competitive advantage in firms", *Organizational Behavior and Human Decision Processes*, Vol. 82 No. 1, pp. 150-169.

3. Betz, F. (2011), *Managing Technological Innovation: Competitive Advantage from Change,* John Wiley & Sons.

4. Calantone, R.J., Cavusgil, S.T., and Zhao, Y. (2002), "Learning orientation, firm innovation capability, and firm performance", *Industrial Marketing Management*, Vol. 31 No. 6, pp. 515-524.

5. Carneiro, A. (2000), "How does knowledge management influence innovation and competitiveness?", *Journal of Knowledge Management*, Vol. 4 No. 2, pp. 87-98.

6. Castro, G.M., Pedro, L.S., and Miriam, D.V. (2011), "Towards a knowledge-based view of firm innovation. Theory and empirical research", Journal of Knowledge Management, Vol. 15 No. 6, pp. 871-874.

7. Chen, L., and Mohamed, S. (2006), "Empirical analysis of knowledge management activities in construction organisations", in *Building on IT Joint International Conference on Computing and Decision Making in Civil and Building Engineering, Montreal*, pp. 1564-73).

8. Chong, A.Y.L., Ooi, K.B., Bao, H., and Lin, B. (2014), "Can e-business adoption be influenced by knowledge management? An empirical analysis of Malaysian SMEs", *Journal of Knowledge Management*, Vol. 18 No. 1, pp. 8-8.

9. Cooper, J.R. (1998), "A multidimensional approach to the adoption of innovation", *Management Decision*, Vol. 36 No. 8, pp. 493-502.

10. Damanpour, F. (1992), "Organizational size and innovation", *Organization Studies*, Vol. 13 No. 3, pp. 375-402.

11. Damanpour, F., and Gopalakrishnan, S. (2001), "The dynamics of the adoption of product and process innovations in organizations", *Journal of Management Studies*, Vol. 38 No. 1, pp. 45-65.

12. Darroch, J. (2003), "Developing a measure of knowledge management behavior and practices", *Journal of Knowledge Management*, Vol. 7 No. 5, pp. 41-54.

13. Darroch, J., and McNaughton, R. (2002), "Examining the link between knowledge management practices and types of innovation", *Journal of Intellectual Capital*, Vol. 3 No. 3, pp. 210-222.

14. Davenport, T.H., and Prusak, L. (1998), *Working Knowledge: How Organizations Manage What They Know*, Harvard Business School Press, Boston.

15. Desouza, K.C., and Evaristo, J.R. (2003), "Global knowledge management strategies", *European Management Journal*, Vol. 21 No. 1, pp. 62-67.

16. Earl, M. (2001), "Knowledge management strategies: toward a taxonomy", *Journal of Management Information Systems*, Vol. 18 No. 1, pp. 215-242.

17. Gunday, G., Ulusoy, G., Kilic, K., and Alpkan, L. (2011), "Effects of innovation types on firm performance", *International Journal of Production Economics*, Vol. 133 No. 2, pp. 662-676.

18. Hall, R., and Andriani, P. (2003), "Managing knowledge associated with innovation", *Journal of Business Research*, Vol. 56 No. 2, pp. 145-152.

19. Hung, R.Y.Y., Lien, B.Y.H., Fang, S.C., and McLean, G.N. (2010), "Knowledge as a facilitator for enhancing innovation performance through total quality management", *Total Quality Management*, Vol. 21 No. 4, pp. 425-438.

20. Lee, V.H., Leong, L.Y., Hew, T.S., and Ooi, K.B. (2013), "Knowledge management: a key determinant in advancing technological innovation?", *Journal of Knowledge Management*, Vol. 17 No. 6, pp. 848-872.

21. Liao, S.H., Fei, W.C., and Chen, C.C. (2007), "Knowledge sharing, absorptive capacity and innovation capability: an empirical study of Taiwan's knowledge intensive industries", *Journal of Information Science*, Vol. 33 No. 3, pp. 340-359.

22. Lin, H.F. (2007), "Knowledge sharing and firm innovation capability: an empirical study", *International Journal of Manpower*, Vol. 28 No. 3/4, pp. 315-332.

23. Lin, H.F., and Lee, G.G. (2005), "Impact of organizational learning and knowledge management factors on e-business adoption", *Management Decision*, Vol. 43 No. 2, pp. 171-188.

24. Lynn, G.S., Reilly, R.R., and Akgun, A.E. (2000), "Knowledge management in new product teams: practices and outcomes", *IEEE Transactions on Engineering and Management*, Vol. 47 No. 2, pp. 221-231.

25. Madhoushi, M., Sadati, A., Delavari, H, Mehdivand, M., and Mihandost, R. (2011), "Entrepreneurial orientation and innovation performance: the mediating role of knowledge management", *Asian Journal of Business Management*, Vol. 3 No. 4, pp. 310-316.

26. Martinez-Costa, M., and Jimenez-Jimenez, D. (2009), "The effectiveness of TQM, the key role of organizational learning in small business", *International Small Business Journal*, Vol. 27 No. 1, pp. 98-125.

27. McAdam, R., and Leonard, D. (2001), "Developing TQM: the knowledge management contribution", *Journal of General Management*, Vol. 26 No. 4, pp. 47-61.

28. Ng, Y.K., Lee, V.H., Foo, A.T.L., and Gan, P.L. (2012), "The relationship between knowledge management practices and technological innovation: a conceptual framework", *International Journal of Management, Knowledge and Learning*, Vol. 9 No. 1, pp. 71-89.

29. Nonaka, I., and Takeuchi, H. (1995), *The Knowledge Creating Company: How Japanese Companies Create the Dynamics of Innovation*, Oxford University Press, New York, NY.

30. Perez Lopez, S., Peon, J.M.M., and Ordas, C.J.V. (2006), "Human resource management as a determining factor in organizational learning", *Management Learning*, Vol. 3 No. 2, pp. 215-239.

31. Porter, M.E. (1985), *Competitive Advantage: Creating and Sustaining Superior Performance*, Free Press.

32. Prajogo, D.I., and Sohal, A.S. (2003), "The relationship between TQM practices, quality performance, and innovation performance", *International Journal of Quality & Reliability Management*, Vol. 20 No. 8, pp. 901–918.

33. Rademakers, M. (2005), "Corporate universities: driving force of knowledge innovation", *Journal of Workplace Learning*, Vol. 17 No. 1, pp. 130-136.

34. Rao, P., and Holt, D. (2005), "Do green supply chains lead to competitiveness and economic performance?", *International Journal of Operations and Production Management*, Vol.25 No. 9, pp. 898-916.

35. Rubera, G., and Kirca, A.H. (2012), "Firm innovativeness and its performance outcomes: a meta-analytic review and theoretical integration", *Journal of Marketing*, Vol. 76 No. 3, pp. 130-147.

36. Scarbrough, H. (2003), "Knowledge management, HRM and innovation process", *International Journal of Manpower*, Vol. 42 No. 3, pp. 25-30.

37. Tan, C.L., and Nasurdin, A.M. (2011), "Human resource management practices and organizational innovation: assessing the mediating role of knowledge management effectiveness", *The Electronic Journal of Knowledge Management*, Vol. 9 No. 2, pp. 155-167.

38. Therin, F. (2002), "Learning organization and innovation performance in high-tech small firms", *Proceedings of International Council for Small Business Conference*, Puerto Rico.

39. Weerawardena, J., O'Cass, A., and Julian, C. (2006), "Does industry matter? Examining the role of industry structure and organizational learning in innovation and brand performance", *Journal of Business Research*, Vol. 59 No. 1, pp. 37-45.

40. Zhang, H., Shu, C., Jiang, X., and Malter, A.J. (2010), "Managing knowledge for innovation: the role of cooperation, competition, and alliance nationality", *Journal of International Marketing*, Vol. 18 No. 4, pp. 74-94.

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GLOBAL UNDERSTANDING OF EDUCATION: IS TEACHING (STILL) PROFESSION?

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ABSTRACT

In this paper the role of teachers is discussed and their role and responsibilities for educating young people. The paper focuss on contraversial role of teachers in modern society and opens question such as: Is teaching (still) profession. On the one hand we advocate that the teacher be profession, but we wonder if it is still profession. We present the situation of being a teacher in Slovenia.

Key words: school, teacher, profession, Slovenia

UNDERSTANDING SHOOLS AND THE ROLE OF TEACHER

Schools are viewed as crucial site in developing democracy and teachers are seen as profesional workers responsible for educating young people in the ideals, goals and practices of a sustainable democratic society. It is inenvitable than, that status of teachers and teaching as profession become even more important when teachers are identified as key factor of qualiy of education.

Despite of different definitions, disagreement over aspects of teaching as profession are not so vast. Profesional model include rigorous training and licensing requirements, active professional organisation, substantial autonomy. Professionals have a high degree of control over their work environments, high prestige, and relatively high compensation (not just as salary) compared to nonprofessionals (Ballantaine, 2011).

Constitutive dimensions of profession are classic deffined as (Etizioni, 1969):
- Specialized knowledge, expertize and professional language,
- Shared standars of practice,

- Long and rigourous processes of training and qualification,
- A monopoly over the service that is provideed
- An ethic of service,
- Self-regulation of conduct, discipline
- Autonomy to make informed discretionary judgements
- Working together with other professionals to solve complex cases
- Commitment to continous learning and professional upgrading.

The article focuss on contraversial role of teachers in modern society and opens question such as: Is teaching (still) profession.

TEACHING AS PROFESSION

Professional work involves highly complex set of skills, intelectual functioning and knowledge that are not easily acquired. Entry to professions requires also credentials – a license which is obtained only after initial training – and serve as sort of gatekeeper for quality assurance (Ballantine, 2011).
Such deffinition can be seen as heritage as tradition that attempts to identify the defining characteristics or *traits* that distinguished the professions from other occupations. The most commonly cited traits were (Runte, 1995):

- skill based on abstract knowledge
- provision for training and education, usually associated with a university
- certification based on competency testing
- formal organization
- adherence to a code of conduct
- altruistic service.

But named traits were indeed never clearly defined. It was never told precisely *how much* training was required, *how esoteric* the theoretical knowledge needed *how restrictive* the certification obtained, and so on, before an occupation could be considered a true profession (Runte, 1995).

There are also other reasons to be cautius using concept of profession. The the conditions of professional work have changed so that the predominant pattern is no longer the same. Different historical context, in radically different work settings, and in radically altered forms of practice is something that must be considerd analysing occupations as social practice. The persistence of concept profession with outdated and untenable model of the professions, and mystification which unconsciously obscures real social structures and relations could become *an ideology* (Larson, 1977, Runte, 1995).

But the danger of idelogising is always present. Having in mind that the concept profession with outdated and untenable model of the professions could lead to the wrong goals we conssider the autonomy of practice of profession as a main trait of teaching as a profession.

On the filed of education two other dimenssions are specially undelined that is in- service training as an instrument of profesional develompent and as extend of specialization for teaching school subjects. Both dimensions are fundamental attributes of any profession but special attention is given to them just on the filed of education. This in-service training to which teachers are assigned to teach subject which match their fileds of speciality and training is also a measure of profession.

The distribution of power, authority and control in schools as part of autonomy of teachers is one of the most important charasteristic of professional status of teachers. Autonomy of teacher is even precondition to promote democratic values if education still remains one of the most important spheres for creating engaged citizens capable for faceing whith challenges of today and future world.

Lose of professional autonomy in schools and classroms cals competence to be important factor of democratic education into question. Because of that to be professionals teachers must enjoy considerable trust and autonomy to make professional judgement.

Importance of professional power, authority and control has been expressed through concept of professional capital. Professional capital is defined as confluence of three other kinds of capital: human, social, and decisional. The presence of these three forms of capital is vital for transforming the teaching profession into a force for common good, for promotind democratic values (Heargraves, 2012, 88).

The importance of social capital is making opportunity to acces knowledge of other. It develops resilence in professional work and is a sort of driver that keeps on growing and giving and stimulates growth of others forms of capital as is decisional capital. Decisional capital as capacity to judge has been acchived trough expirience, practice and reflection. As professional decision is essential dimenssion of profesional capital than professional autonomy of teachers is inevitably.

On the other hand we are faced with proces where most EU countries have developed explicit standards for the teaching profession. Teacher standards as professional profiles have been developed as key factor of improving quality of the teacher and as general descriptors for the most important qualities. The main question is than to which steep this efforts contibute to strenghtening a professional capital?

A study of national documents which includes the descriptions of teacher qualities in 12 EU countries revealed (Snoek, 2009) that indicators of quality of teachers are elaborated and detailed but there is no agreement about types of categories for structuring teacher qualities.

Three types of categories for structuring teacher qualities in national levels have been distinguished.

- A structure based on teacher functions or main areas of expertise. Examples are Belgium, which refers explicitly to teacher roles (teacher as a researcher, organizer, culture participant, Snoek, 2009) and The Netherlands, Norway, Slovenia, ETUCE and the EC document Improving the Q of TE, which all refer to specific domains of expertise.
- A structure based on the different context in which a teacher has to operate: within the classroom/with pupils, within the school/with colleagues, within society, with himself/professional development, with knowledge. Examples are Belgium, Czech Republic, The Netherlands, Slovenia, OECD, EC Improving the Quality of TE, EC Common European Principles.
- A structure which is based on the more abstract categories of knowledge, skills and attitudes/personal attributes. Examples are England, Sweden, Poland (only skills) and Belgium (attitudes) (Snoek, 2009).

European documents on teacher quality show a similar picture. The *teaching competence* (pedagogical/didactical competence) and the *competence of cooperation* are the most frequent.

Advocate of shared frame of reference for teacher quality emphasized that it could create a common language that can facilitate effective exchange of policy practices between member states, mobility of teachers and cooperation between schools and teacher education institutes. Efforts to detaile indicators of quality of teachers in national and Eu documents pose some questions such as could this processes contribute to certain limitation of professional capital of teachers specially if competencies are defined in a detailed manner?

Colud introduction of detailed teacher standards be seen as a path to expand and strenghtening instrumentalisation of teacher work? Is there a danger of understanding educational reform as creating data systems to measure how people teach and learn effectively and positioning teacher as administrators?

SITUATION IN SLOVENIA

Qualifications and working conditions of pedagogical staff in are prescribed quite detailed by general national regulations and includes:
- profiles of pre-school and other teachers who teach at each level of the education system (from pre-school to higher education);

- general qualification conditions (level, professional knowledge, knowledge of the language of instruction);
- competencies for making decisions about their qualifications according to the subjects or subject areas;
- undergoing traineeship and taking the teaching certification examination;
- competencies and procedures regarding employment and dismissal;
- specific characteristics of working conditions (field of work, teaching obligations, advancement), and
- professional development.

Teachers and pre-school teachers at all levels of public education are public servants. Public servants' salaries, labour relations and retirement are unified across the state. These should garantee equitable position of teachers in all counties. According to results of international comparative study in wich Slovenia was involved - TALIS- teacher self – efficacy and job satisfaction are above the TALIS avreage. Average classroom disciplinary climate is viewed positively and the precentage of lesson time lost to disruptive student behavior is relatively low (Dupona Horvat e al, 2013).

Almost 97% of teachers participate in professional development activities in the survey period. Almost 85% of teachers pay nothing for the development they recived. Around 35% teachers wanted more development they recived, the areas of greatest interes are students with special learning needs, student discipline and behaviour problems. According to results of TALIS teachers in Slovenia predominantly see their role as faciliator of active learning.

Results of student acchivements in PISA 2009 and TIMSS 2011 are especially good on science and math and significant advancement on reading literacy (PIRLS 2011, Dupona Horvat et. al, 2013).

But on the other hand students do not like scholl (TIMSS 2011) and teachers are exposed to burnout. The results of the TIMSS and PIRLS surveys show that the Slovenian teachers are less satisfied with their careers than the international average and at the same time recognize that their enthusiasm for the work of years of teaching dropping more than applies to the international average (Dupona Horvat e tal, 2013). Less than in the other analyzed countries have also agreed to carry out important work. This is somewhat unusual, because otherwise the education enjoys great public confidence (Dragos, 2013). On the other hand, the Slovenian teachers strongly denied the statement (90%) that they work as teachers frustrates (Dupona Horvat, 2013).

Burnout had previously been a malady of novice teachers; the highest burnout rates occurred among teachers with less than 5 years of experience. Now more experienced teachers became more stressed than novices (Ballantine, 2011). Causes for this situation can be seen in five dimensions of alienation (Seeman, 1975) that is: powerlessness, normlessness,

meaninglessness, isolation and estrangenet. Causaul elements for burnout are obviously seen within the structure of the educational system (Dworkin, 2001).

Staus of teachers obviously demands more complex and contects related analyse. Understanding of how these massive teachers feeling of powerlessness, normlessness, meaninglessness, isolation and estrangenet are related to the larger crisis of neoliberalism (even casino capitalism, Giroux, 2011).

IS TEACHING STILL PROFESSIONf?

The possession of an esoteric knowledge base, a long and substantial amount of training required for entrance, the existence of professional association that can speak authotitatively for the occupation, a code of ethics, siginficant professional autonomy are important aspects of professional practice. At the same time the status of teachers and teaching is havelly dependent on policies and politics that can create recruitnment easier, they can change teacher certification, enhance the status of the occupation. Is teaching than semi profession or even is not profession (Strike, 2007).

It seems that the main charcteristics that teaching is still profession is autonomy and self – governance of teachers. The relation between the impositon of different kinds of control of state and the level of autonomy and self goverenance of teachers is than the touchstone of their professionalism. Usually it is defined within the concept of quallity of teachers and teaching which makes the concept of quality even more important.

We are faced with different approaches to quality but a lot of them are based in positivistic tradition and imposition of different empirically examined standards for teachers and students through which the efficency of pedagogical process can be proved. Defining schools exclusively in terms of mathematical coordinates and statistical formulas reduced teachers just to civil servant, limited to teaching standardized lessons memorization and test-taking skills in an effort to get schools to race to the top. The emphasis on the practical and data driven performance reduct education to the prison of instrumentalism. In such position teacher lose professional autonomy and essential meaning of educational work. They become indifferent to the etical and political dimensions of their own authority and practice.

This could reconfigure education in instrumental terms where the complexity of wider society is neglected and educational process seen as just management problem. The logical consequence is that teaching and learning is than divorced from matters of ethics and theory. Teachers are constructed as techinicans who have no need for something as abstract as a public vision through which to imagine the democratic role and social responsibility (Giroux, 2011).

Even anti –intellectualism can been strenghtened through narrowly defined national teacher standards and certification of in- service programs based on simplified form of skill based methods and instrumental training.

Conception of teaching as profession is knowledge base and should make subject matter competence a central concern. It should be focused on teacher ability to understand the epistemological position of the learner and on those activities that are conceptually essential to teaching instead of focusing just on identifying indicators of good teaching. Professional autonomy is than closely associated with academic freedom (Strike, 2007). Lenghtening the period of training and defined detailed teacher standards do not automatically improve quallity and competencies of teachers. It is important that teaching is grounded in intellectual practice, associated with epistemology of disciplines so that can represent their internal goods. The teaching strategy wich pursue strategies that represent all knowledge, including their own, as merely instrumental will reinforce attitudes which will ultimately diminish the status of teachers as professionals.

Education should be seen as human capital formation which makes learning of instrinsic worth. Matters of education should be taken seriously if we are going to survive as democracy. But for realisation of both, self governance and autonomy it is important that teaching is grounded in a knowledge base that is esoteric and that is not framed in positivistic or even neoliberal pedagogical strategy. Where the life of the mind is valued, techers who see themselves as it emissaries will be valued for that reason. Pherhaps effective teaching, like happiness, is a consequence of being concerned with something of intrinsic worth and with one s integrity in pursuing something of worth. When teaching and learning neglects matters of critical thinking, power creativity, and the power of imagination it loses its hold in preparing young people for democratic future.

It is so because teaching rapidly losing main traits of professions defined in 70-es and even before? There are few reasons why this colud be true. As education levels rose among the general professionals began to lose their status as the only educated, literate members of the community. Computers have become increasingly sophisticated and become main sourse of information so that at the certain level can replace previous professionals' knowledge. New occupations have arisen. This are also first signs of deskilling process which refers to four processes:

- the process whereby worker loses the right to design and plan; i.e., divorce of planning and doing;
- the fragmentation of work into meaningless segments;
- the redistribution of tasks amongst unskilled and semi-skilled labour, associated with labour cheapening; and
- the transformation of work organization from the craft system to modern, Taylorized forms of labour control (Runte, 1995).

And teachers have always been and subject to direction from governament and the provincial bureaucracy. Are they than, to a certain degree already proletarianized.As the professions lose their monopoly over particular bodies of knowledge, they also lose the rationale for their special status as professions.

Despite all metioned in fact teaching is a complex process that can not be completely monitored nor by govrnament not by local autority. So the real issue is the degree to which teachers can resist deskilling and maintain some measure of autonomy. Deskilling of teachers can not be in the public interest. The quality of education depends heavily on the quality of teacher work. The quality of the teacher's work is only possible where teacher autonomy is high.

LITERATURA

- Ballantine Jeanne H., Hammack Floyd M. (2011) *The Sociology of Education* (7th Edition) Pearson.
- Dupona Horvat Marjeta et al (2013). *Pregled podatkov o pogojjih poučevanja in delu učiteljev in učiteljic iz raziskav TIMSS in PIRLS 2011*, Pedagoški institute Ljubljana.
- Dworkin A. Gary (2001) Perspectives on Teacher Burnout and School Reform, *International Education Journal* Vol 2, No 2
- Etzioni Amitai (1969) *The semi-professions and their organization: teachers, nurses, social workers.*New York: Free Press, 1969.
- Giroux, Hennry (2011) *On Critical Pedagogy*. Continuum Press
- Hargreaves Andy, Fullan Michael (2012) *Professional Capital: Transforming Teaching in Every School,* Teachers College Press, New York
- Larson Magali Sarfatti (1977), *The Rise of Professionalism: A Sociological Analysis* (Berkeley: University of California Press
- Littler, Craig (1982) *The Development of the Labour Process in Capitalist Societies: A Comparative Study of Work Organizations.* Heinman Educational Books
- Runté, Robert (1995) *Thinking about Teaching: An Introduction.* Toronto: Harcourt Brace
- Seeman, Melvin (1975) Alienation Studies, *Annual Review of Sociology* Vol. 1
- Snoek Marco et al. (2009) *Teacher quality in Europe: comparing formal descriptions*: paper ATEE conference 2009 Malorca
- Strike Kenneth, Moss Pamela (2007) *Ethics and College Student Life: A Case Study Approach* (3rd Edition) Prentice Hall