

Structures of Strategic Management of Technology in a Conceptual Framework of Enterprise Practice

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Abstract

Purpose – The purpose of this research is to introduce structures of strategic management of technology as elements in a conceptual framework.

Design/methodology/approach: The approach of this study is abductive. The original framework is expanded and validated through inference to findings of large and small to medium-sized enterprise practices through interviews, finally ending on theory matching.

Findings – The entire field of MOT (Management of Technology) is perceived complex, and there is contingency and immaturity in practices. Practitioners unanimously consider the elements of strategic management of technology as important for sustaining enterprise competitiveness. We suggest that strategic technology management should be evolved as a distinctive managerial discipline in multifunctional organizations. The need for systematic MOT practices in a company changes over time, depending on the life stage and size of the company. As a company matures and grows, management of technology practices can be assumed to develop accordingly.

Research limitations/implications – This research did not intend to reveal how practices are implemented, or what their maturity, effectiveness and efficiency is. The framework presented in this paper is suggested to provide premise for further theory development and to be applicable as a frame of reference for designing strategic MOT practices in enterprises.

Originality/value: In the absence of commonly agreed frameworks, elements of strategic technology management are discovered in this paper. For the framework development, integrated management theory is applied to consider technology management in strategic dimension. Companies should consider establishing and integrating strategic technology management as a distinguishing managerial discipline amongst other organizational functions.

Keywords – strategic management, technology management, MOT, framework, synergy.



1. Introduction

1.1. Background and the research questions

Competitiveness and value creation of enterprises are, in the long-term, enabled by successful execution of a company's strategy in which technology is a critical resource. Competitive environment is involving increasingly rapid changes in technological, social and economical circumstances, therefore effective and efficient technology management practises are important during all life-stages of an enterprise. In the fields of strategic management, knowledge management and technology management, there is extensive ongoing research on various aspects of enterprise innovativeness and competitiveness in the realm of global competition. Capability of strategic management of technology (MOT) is imperative for sustained competitiveness of an enterprise (e.g. Mei and Nie, 2008; Verdu-Jover *et al.*, 2008). Technological information and knowledge requires codification and systematic management for accessing, storing, sharing and deploying it for business benefits and productivity (e.g. Ho, 2008; Paliszkiwicz, 2009). Complexity of the subject and lack of comprehensive frameworks give rise to managerial challenges in all sizes of enterprises. Common perceptions of technology management are not well-suited for coping with the complexity of the field (Chiaromonte, 2003; Drejer, 1997; 2002; Levin and Barnard, 2008), therefore, a consistent framework with insights on the elements of strategic management of technology, is needed.

Current conceptual frameworks are poorly defined which leads into introduction of diverse empirical solutions (Farrukh *et al.*, 2004; Phaal *et al.*, 2004). These diverse solutions are focused on e.g. portfolio management and road mapping (e.g. Phaal *et al.*; 2007 Walsh, 2001). Technology management is often seen as managing R&D, for which Edler *et al.* (2001; 2002) have defined the key principles for the so called 4th generation R&D. Nevertheless, these principles do not comprehensively address the key elements of MOT. Existing frameworks do not properly cover environmental, economical or social aspects (Brent and Pretorius, 2007) either. Levin and Barnard (2008) have created an organizing scheme on technology management routines based on large company practises. Small to medium-sized enterprises (SMEs) have to face similar problems as large enterprises, but with limited resources for technology management (Savioz, 2006).

The practical problem for enterprises is to define what elements are needed for strategic management of technology, in order to establish and improve the practises in a company. The main research question (**RQ**) is to define what the elements of strategic technology management are. The conceptual framework for strategic management of technology, introduced in our earlier research (Sahlman and Haapasalo, 2009; 2011a; 2011b), is originating from large enterprise practise and literature findings. The purpose of this study is to amend the framework, and to increase its validity. The focus of this study is on the *structures* part of the strategic MOT framework, and the emphasis is on management of product technology. To gather empirical information for validation of the framework, two research questions are formulated:

RQ1: What is the perception of strategic MOT practises in SMEs?

RQ2: What is the current state and importance of the MOT practises in SMEs?

1.2. Evolvement of the framework

The approach for developing the framework is abductive. In abductive reasoning, inference is sought out from the interrelated information to provide possible explanation to the object under study. Abductive reasoning has been a common approach in qualitative research. It provides for the researcher simultaneous data collection, theory development, and the theory building elements (Dubois and Gadde 2002). The primary aim of this approach is to develop an understanding of the phenomenon for theory development (Arlbjørn and Halldórsson 2002). So called ‘theory matching’ or ‘systematic combining’ is used for the search of suitable theories to base on empirical observation. There is interplay between matching theory and empirical findings, which contains learning and feedback during the study (Dubois and Gadde 2002, Kovács and Spens 2005, Taylor *et al.* 2002). The initial framework describes the proposition, which is expanded on and validated through the results of this subsequent research. The initial framework was developed earlier, based on a large enterprise practise, and that study is not in the scope of this paper. The methods used in this research to obtain the data for abductive reasoning was interview and a questionnaire, results of which were analyzed to evolve the framework. The logic of how the empirical data is connected to the proposition is based on comparing and matching of the developed initial framework with the results of the conducted interviews in SMEs. It was expected that SMEs are strategically focused enterprises and concentrating on the most essential activities for the company’s success, so findings on technology management activities among SMEs would reveal the most important ones. Consequently, information is gathered from multiple sources and to find the best possible description for the elements in the framework. It is expected that the results support the contents of the initial framework, thus increasing its validity. Proceeding of the study is presented in Figure 1.

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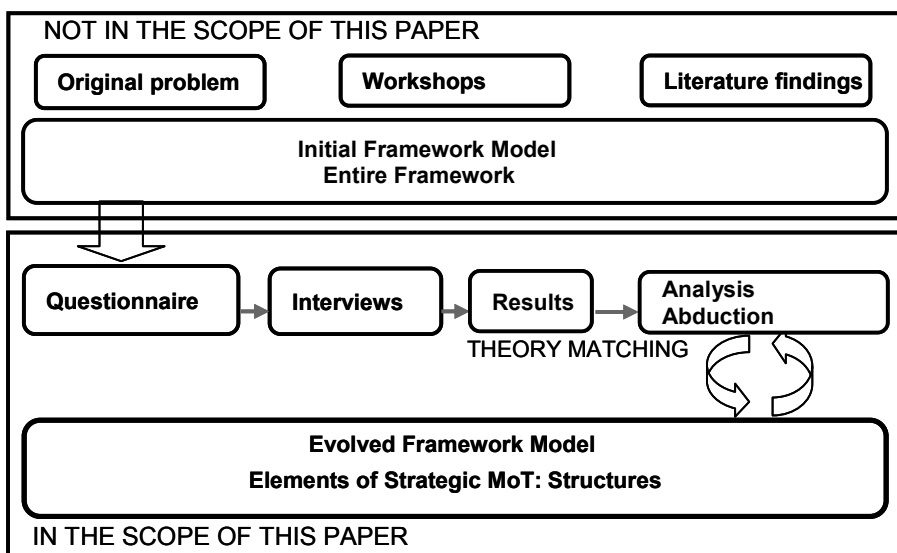


Figure 1:
Proceeding of the study
and evolvement of the
framework.

The empirical study was carried out in 18 Small to Medium-sized Enterprises in Northern Finland in the region of the city of Oulu, in the fall of 2008. Due to practical reasons, but compliant to requirements of qualitative research (see Yin, 2003), the geographical scope was limited to enterprises having premises and personnel in the Oulu area, to ensure availability of the interviewees, and for efficient use of the research resources. The sample of the interviewed companies has global market, customers, competition and operations. The companies are designing, manufacturing and providing electronics, mechanical, medical instruments and software products, solutions and services. The criteria for selecting the sample were companies' exposure to high-technology business environment. The 25 interviewees were persons responsible on functions dealing with the topics of technology management i.e. business, product, technology and R&D management, typically company founders and senior managers of the companies. Working experience of the interviewees was between 15 to 25 years. The number of employees in the interviewed SMEs varied from less than 10 to around 250, and turnover varied from less than 2M EUR up to 50M EUR. The companies were selected to be in the limits of the definition of SME by Commission of European Union (2005). The structural questionnaire (Appendix 1 and 2) consisted of 12 open qualitative questions and 18 closed questions to be quantitatively evaluated by the interviewees. Due practical reasons the number of questions was reduced from a total of 48 to 30, after running a test interview. The instrument used in this research was the relative scale from 1 to 5 for evaluating importance and current state of the practice. To avoid expression of preconception to the interviewees, the open qualitative questions were asked first to elicit perceptions of the interviewees to MOT in free form. The closed quantitative questions, which were derived from the framework, provided for the interviewees a frame of reference to identify the elements of management of technology, regardless whether the elements were familiar to the interviewees in advance or not.

2. Context of strategic MOT

2.1. Strategic MOT in the context of enterprise management

Strategic management of technology within a company contains aspects of explicitly linking business strategy with the products and the required technologies. Efficient and effective management approach is needed for MOT, which is more complicated than the traditional management of research and development, due to its dynamics and fundamental impacts on company's strategy, products, competitiveness and people's knowledge. Strategic MOT in the form of processes and practises shape capabilities of a company internally, and with respect to its socio-economic environment. Therefore, it is practically intertwined with all management activities and operations of an enterprise. The key topics that are related to strategic management of technology in the context of enterprise management are presented in Figure 2.

As classically defined, strategic management concerns the company's initiatives taken by the management to create, enhance and sustain its capabilities, regarding to its environment to reach the company's objectives (Ansoff, 1979). From a strategic

management perspective, the mission of an enterprise is to create value for owners, personnel, customers, suppliers and society (e.g. Kaplan and Norton, 2004). To create value, a company has to determine and structure its position in the value chain through the defined strategies and the operative actions that execute the strategy (Porter, 1985). According to Teece et al. (1997), in a rapidly changing technological environment, a company's competitiveness is determined by its ability to co-ordinate and to combine its technological assets dynamically. The assets that are needed to accomplish the company's mission are defined by the business model the company pursues. The business model consists of offering, value creation system and revenue logic (e.g. Chesbrough, 2006; Suikki et al., 2006). Thus, strategic management of technology need to cover technology aspects of the business model, which is determined by the company's type of business and by the competitive strategy of the company. An enterprise possesses and may acquire competencies and resources to execute its strategy. These resources, and the distinctive competencies, determine the company's ability to compete. For the creation of value, a company can be structured according to perspectives of customer, financial, internal and learning processes (e.g. Kaplan and Norton, 2004), which are intended to be executed as cross-functional and cross-organizational processes. Typically, technology management is not organized as its own function, as it is often embodied in the R&D function. Therefore strategic management of technology imposes a major paradigm change on organizing MOT as a distinctive function in an enterprise.

Steele (1989) categorizes technology to product technology, manufacturing technology and information technology. According to Burgelman et al. (2001, p. 8) technology is embodied in people or systems as explicit artefacts or tacit knowledge. Technology management can be seen as activities being involved from research and development of technology for products throughout to commercialization and abolishment of the products (Dodgson, 2000; Khalil, 2000). Generic processes of identification, selection, acquisition, protection and exploitation (Gregory, 1995) and technology strategy creation, technology development and disposal (Sahlman and

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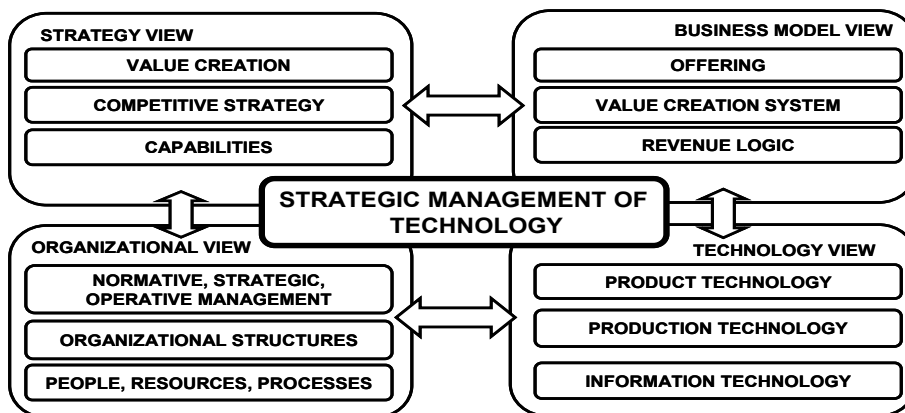


Figure 2:
Context of strategic management of technology

Haapasalo, 2009), covers MOT activities. Within this context, the elements of strategic management of technology structures, objectives and impacts, form the framework for strategic MOT. In this paper, the following definition (Sahlman and Haapasalo, 2009) for strategic management of technology is used:

“Strategic management of technology is planning, organizing, leading and controlling of technological activities, interacting with the company’s skills to apply knowledge, structures, resources and socio-economic environment, to contribute to formulation and execution of the company’s basic, long-term goals and objectives, and adoption of courses of action and the allocation of resources necessary for those goals.”

2.2. Overview of the Strategic MOT Framework

The strategic management of technology framework is presented in Figure 3. It defines management dimensions of normative, strategic and operative, each consisting from the elements of structures, objectives and impacts. The framework is based on the integrated management theory of Bleicher (2004). The model was originally used by Tschirky (1991) and Luggen and Tschirky (2003) in the context of technology management. In our research the integrated management model is applied to comprise the framework for the strategic management dimension.

The framework is a conceptual model that describes a hierarchical structure of the elements in an open system. The elements are assumed to have interaction and interconnections with each other, and towards the environment they are operating in.

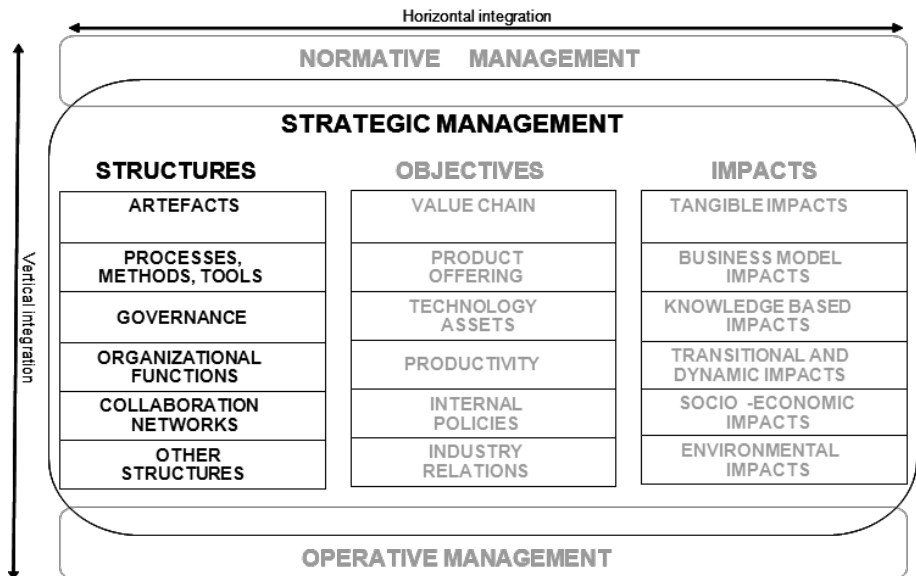


Figure 3:

Main elements of the initial strategic management of technology framework

The model describes structures, objectives and impacts as elements of the framework. In the framework model, normative management dimension is about defining the company's fundamental mission and values within the socio-economic environment it operates in. Normative management forms the base for the strategic management, in terms of constitution, governance principles, culture and mission of the company. Plans that are formed in strategic management dimension get realized through operative activities to accomplish the company's mission. Operative management is concerned with the activities that take place in reality. Activities utilize resources, processes, practises and methods to produce intangible and tangible outcomes inside and outside of the company. These activities shape the firm's technology infrastructure and influences external environment.

Major categories are classified into sub-categories that contain the elements at the next level of detail. Theoretically the structures, objectives and impacts are the classified key viewpoints to strategic management of technology. In the strategic management dimension, objectives are classified to value chain, product offering, technology assets, productivity, internal policies and industry relations related technology management objectives. Objectives need to conform to the company's strategic objectives and their realization contributes on definition, execution and shaping of the corporate strategy. The impacts of strategic management of technology classifies tangible, business model, knowledge based, transitional and dynamic, social and environmental impacts. The structures are initially categorized as artefacts, processes, methods, tools, governance, organizational functions, collaboration networks and other structures.

3. Structures of strategic management of technology in enterprise practise

3.1. Definition and purpose of management of technology

In the interviews, the definition of MOT came across as quite a difficult and a comprehensive concept. MOT is understood to be an important base for the products and for product creation. It is dependent on the development stage of the company and the business environment in which the company operates. The starting point and purpose for MOT is to fulfil customer needs that lead into business opportunity. It is essential that adequate technologies are available for the business goals, and that technology provides competitive advantage. Main elements that are recognized are identification, selection, acquisition and development of technology, to be used in products.

Management of technology is mostly seen as an implicit activity, intertwining with the company's business, product management and product development. The basis for MOT is assumed to be derived from company strategy and customer needs. Typically, MOT is practised unconsciously, and it is not exercised systematically. Thus knowledge of the individuals on technology is utilized implicitly, especially at early stages of the company development. The scope of MOT is perceived to be people, knowledge, competence, architectures, products, tools and methods, software, and IT systems.

3.2. Key practises on management of technology

Key practises on Management of Technology are mentioned to focus on follow-up of the trends and gathering information of the available technologies. The results of the practises are reports on competitor analysis, technology benchmarking, technology reviews, evaluation and tests. Artefacts that are mentioned are company strategy, business and product plans, customer feature requests, product roadmaps, technology roadmaps, technology forecasts, lists of the technology portfolio, and links to the information references. Many of the interviewees mentioned specifically that there are no systematic processes or formal practises defined for MOT. Planning of the technology management activities is happening as part of the business planning i.e. during the product planning and budgeting. Planning may take place annually or when new opportunities and customer needs have been identified.

Decisions on technology related topics are usually made on the principles, guidelines and policies that are derived from the business and product strategy. Various types of decision-making bodies like leadership teams, product development management teams, steering teams and product councils, are mentioned. The bodies make decisions on a regular basis. Make or buy and collaboration decisions are made, as well decisions on what technologies are used for product creation. Decisions are concerned with the product platforms, technology blocks, modules, components, interfaces, tools, methods, investments, costs, roadmaps and timing.

Clearly technology has to satisfy customer and product requirements in terms of features, quality, usability, performance, reliability, security and energy efficiency, to name a few. Important is time-to-market and the timing of the product releases. Fundamentally, availability of good quality technology is sufficient for the most of the companies since differentiation comes through application of the technologies to fulfil the customer needs. Companies also differentiate through the profound knowledge and expertise on customer problems and processes. They rely extensively on people's knowledge on the technologies, and they count on people's inherent innovativeness.

3.3. Importance and current state of MOT practises in SMEs

According to the evaluation results (Figure 4), all artefacts were seen as at least somewhat important by almost all of the companies. Technology strategy, technology deployment plans and existence of internal guidelines seemed to be regular for all of the companies. Importance of technology forecasts scored high in evaluation, obviously due to the uncertainty of the business and technology environment. Technology maps, technology roadmaps and architecture roadmaps were seen as important by the majority of the interviewees. Typically larger and older companies perceived road mapping more important. The technology research plan was also seen as important by all of the companies, except by two companies that were in the start-up phase.

Although technology strategy was seen as the most important artefact, less than one third of the companies had technology strategy properly practised (Figure 5). Only one of the companies said it was well-established. The best practised activity was the technology deployment plan. Architecture roadmaps had the most distribution in the responses. Only few companies said that they have technology forecasts properly

practised, which may indicate that forecasting is the most difficult activity to perform amongst the day-to-day business practises. Technology maps and roadmaps were practised by one fifth of the companies. This indicates that the span of product and technology planning is relatively short in SMEs. Technology research planning was practised by less than one fifth of the interviewed companies, which is indicating focus on short-term product and business priorities of product development activities. Internal guidelines and standards were seen important by almost all of the companies and practised at mostly at least occasionally.

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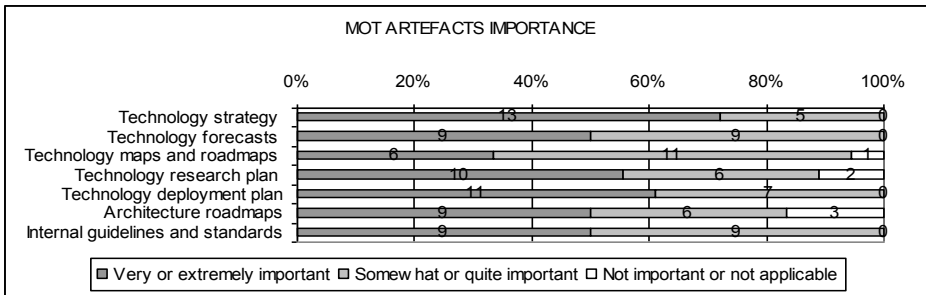


Figure 4: Importance of MOT artefacts

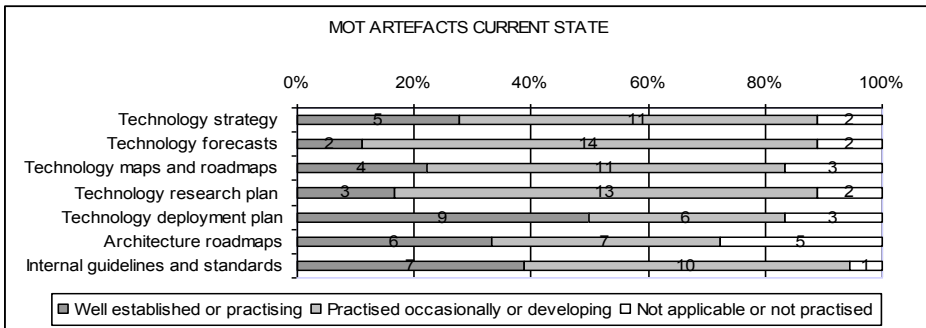


Figure 5: Current state of practise of MOT artefacts

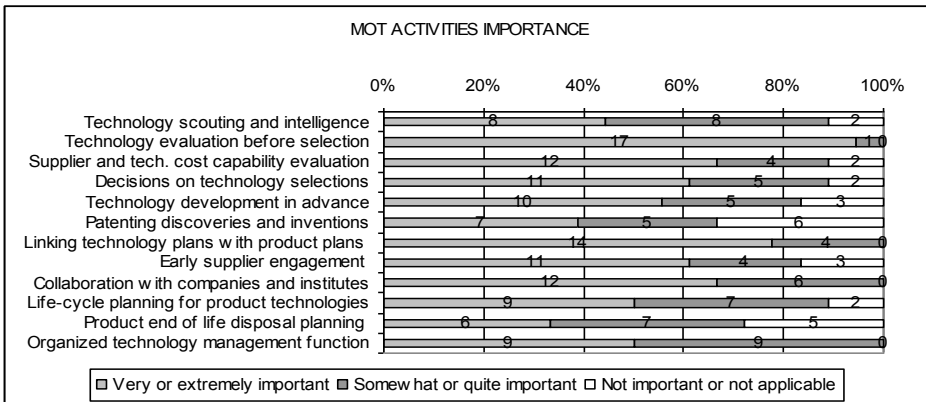


Figure 6: Importance of MOT activities

The result of the evaluated importance of technology management activities is presented in Figure 6, and the current state of practice of technology management activities is presented in Figure 7. The highest ranked activities are technology evaluation and linking the technology plans with the product plans, which is a natural priority for a high-tech company. Companies also must concentrate on their own core, which is indicated by the importance and current state of collaboration and supplier engagement. Consequently importance of the supplier and technology cost capability analysis is high. One third of the companies indicated that they are making systematic decisions on technologies, and almost all are practicing it at least occasionally.

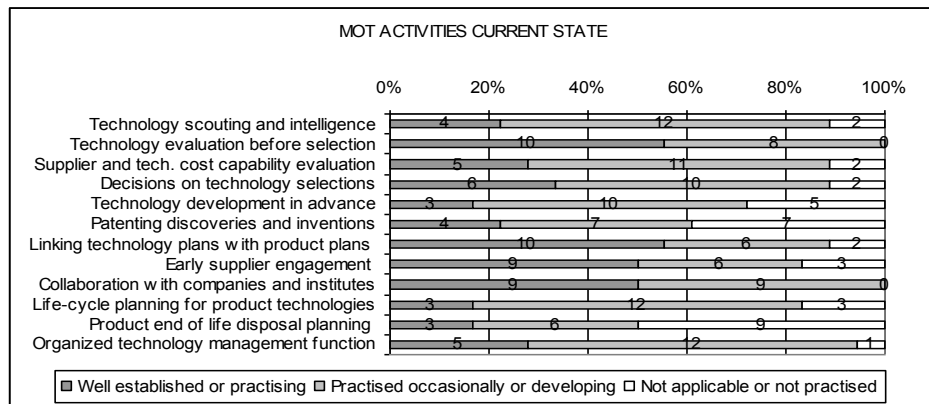


Figure 7:
Current state
of practise of MOT
activities

Technology development in advance was seen as quite or extremely important by the majority of the companies. Less than a half of the companies saw technology intelligence that much important, which is reflected by the low current state of the front-end activities. High-tech SMEs typically have focus on getting first products into market. Product technology life-cycle planning and end of life or disposal planning were seen very or extremely important by many, but practised only by few of the companies. One third of the companies did not see patenting applicable or important at all for them. Based on the interviews, most of the SME companies did not have resources for expensive and time consuming patenting. Although the current state of practises is quite diverse, all the companies saw an organized technology management to have at least some importance for them, and they are practicing it at least occasionally.

3.4. Evolved strategic management of technology framework

3.4.1. Elaboration of the framework

Based on the analysis, the perceptions of the interviewed company representatives reflect well against the elements of the proposed framework on MOT. Thus, the research findings back up the initial proposition on what belongs to strategic management of technology. Although only a sub-set of the topics related to the elements were practically possible to include in the questionnaire, all the main categories were covered in the interviews.

The classification in the framework is not asserted to be exhaustive. Nevertheless, the interview findings correspond with the framework classification, as was expected. Based on the interviews, new categories were not identified. The elaborated main categories of the *structures* part of the framework are described in Table 1. The main change at the top level was to separate the process category from methods, tools and IT systems, in order to better reflect practical and logical classification in the framework.

The detailed sub-structures of the final framework model were elaborated by reflecting the interview findings with the initial framework. The interviewees were not aware about the classification, therefore the construction of the framework is solely made by our own judgment. For example, technology scouting, intelligence and forecasting are separately covered in the questionnaire, whereas in the elaborated framework, all these activities are assigned to the process area of identification. In the final framework the identification process area includes activities of scanning, scouting, monitoring, intelligence and forecasting.

Most of the terms, concepts and practise areas of the initial framework were recognized and covered in the interview results. They were also evaluated to be important by the majority of the interviewees. This was an expected result as the MOT topics in the questionnaire were assumed to be relevant to the company representatives, although the current state of the practises varied.

ELEMENTS OF STRATEGIC MANAGEMENT OF TECHNOLOGY: STRUCTURES	
Main category	Definition
ARTEFACTS	Information, documents, reports, plans, prescriptions as the outcomes of the performed processes of MOT.
PROCESSES	Procedures and practises performed to transform inputs into artefacts of MOT.
METHODS, TOOLS, IT SYSTEMS	Techniques and tools to perform tasks of the procedures and practises of MOT. Information systems for processing and storing artefacts generated in the processes of MOT.
GOVERNANCE	Management structure, definition of authorization and policies for decision-making of MOT topics.
ORGANIZATIONAL FUNCTIONS	Managerial disciplines of an organization for planning, organizing, leading and monitoring MOT functions.
COLLABORATION NETWORKS	Stakeholder organizations involved in company's processes of MOT.

Table 1:
Main categorization of
the structures part of the
framework

3.4.2. Structures of the strategic management of technology framework

The proposed classification of the main categories of the framework is presented in Table 2. The names of the main categories are highlighted with *italics* in the following text. In the framework the major categorization of the technology management *processes* contains processes of technology strategy creation and planning, identification, selection, acquisition, protection, development, exploitation and disposal of technology.

Each of the processes typically can have several sub-processes and practises e.g. identification of technologies consists of practises for technology scanning, scouting, monitoring, intelligence, forecasting and research. The *artefacts* are the major outcomes of the operative technology management activities that are using processes, resources and knowledge. All the artefacts become included in the technology infrastructure of the company, and they need to be strategically managed. Creation and utilization of the artefacts require appropriate *methods, tools and IT systems* for data and knowledge management. Methods, especially for the collection and analysis of information, are needed for operative activities, and planning methods are needed for managerial tasks. Engineering methods and tools are required in research, creation and development of technologies. Data and knowledge management systems form the IT backbone of the technology infrastructure. They are used as for the repository of the technology assets, and utilized to co-ordinate and plan the exploitation of the technological assets in the company.

Organizational functions for technology management depend on the business, size, traditions and principal decisions about the degree of centralization or de-centralization of the business units and other functions in an organization. Processes of strategic MOT require corresponding management functions, and personnel for strategic management activities and for operative execution. For example, a company needs to manage operative activities related to research, technology creation and development, intellectual property and collaboration. *Governance* structure, principle models and criteria for decision making are needed. Effective decision making is the key element to communicate and co-ordinate the execution of the technology strategy, and to set priorities for strategic actions and use of the resources. Different types of alliances, coalitions and agreements form the basic structures for strategic collaboration. *Collaboration networks* consist of institutes, sub-contractors, suppliers, industry analysts, regulatory bodies, customers and even competitors. For each of the elements of the framework, there exists a significant body of knowledge with experiences of how to organize and implement them, thus having an endless potential for deeper study.

4. Discussion and managerial implications

Companies have converged since 1960's from a single-function orientation to a multifunctional strategic orientation, due to the continuing and accelerating turbulence and complexity in the marketplace (Ansoff, 1987). In such a business environment, strategic management of technology is crucial for large and small companies to manage technology evolution and deployment. Technology is the essence of capabilities and offering in enterprises. MOT is a relatively young discipline, compared to strategic management, marketing and product management. Strategic MOT has been researched by scholars increasingly some 20-30 years as an own discipline (Cetindamar et al. 2009; Larson, 2007). Still, it is not clearly distinctive as a managerial function or a discipline amongst the other management disciplines.

In line with the presumptions, the results of this study confirmed that the field of MOT is perceived as a complicated and somewhat confused field by practitioners in SMEs. MOT is seen as important and the topics in interviews were seen relevant,

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ARTEFACTS	
Technology strategy	Technology portfolio
Technology forecasts, trajectories, reports	Technology portfolio development plan
Technology map	Technology portfolio exploitation plan
Technology roadmap	Technology portfolio repository
Architectures	Internal/external technical guidelines, policies
Architecture roadmaps	Internal/external technical standards
Research portfolio	Supplier & collaborator portfolio
PROCESSES	
Technology strategy & planning	Development
Technology outlook analysis	Technology improvement
Technology SWOT analysis	Technology re-architecting
Technology planning	Technology platform creation
Identification	Protection
Technology scanning, scouting	Patenting
Technology monitoring	Trademarks, copyrights
Technology intelligence	License management
Technology forecasting	Encryption
Technology research	Standardization
Selection	Exploitation
Technology evaluation	Technology road mapping
Technology benchmarking	Technology portfolio planning
Technology feasibility analysis	Technology assets accounting
Technology cost capability analysis	Technology lifecycle planning
Technology performance analysis	Technology insertion, refresh
Supplier evaluation, cost capability analysis	Technology retirement
Competitor analysis	Technology licensing
Acquisition	Disposal
Company acquisition, procurement	Technology end of life planning
Technology licensing	Technology disposal planning
Early supplier engagement	Competence circulation
Technology creation	Competence stockholding
TOOLS, METHODS, IT SYSTEMS	GOVERNANCE
Information management methods & tools	Decision making structure
Knowledge management methods & tools	Decision making points, subjects
Analysis & planning methods & tools	Decision making metrics, criteria
Engineering methods & tools	Technology policies and guidelines governance
ORGANIZATIONAL MANAGEMENT FUNCTIONS	COLLABORATION NETWORKS
Technology strategy management	Research collaborators
Technology planning management	Research institutes
Technology portfolio management	Technology sub-contractors
Technology architecture management	Standardization collaborators
Technology assets management	Industry alliances
Technology policies & standards management	Technology communities
Technology creation management	Strategic suppliers
IPR management	Customers
Standardization management	Regulatory authorities
Supplier base management	Industry analysts
Collaboration management	Competitors

Table 2:
Elements of strategic
MOT: structures part of
the framework

although practises were not systematically established in the interviewed companies. The content of the framework is regarded to be relevant and valid for practitioners, as it has been evolved based on large and small to medium-sized enterprise practises.

In the study of Levin and Barnard (2008), technology management was analyzed as a set of organizational routines, as company's evolved capabilities for technology management. The framework attempts to clarify the concepts for practitioners and scholars. The four classes contain the operative routines of knowledge creation, transformation of the knowledge into artefacts, matching artefacts to user requirements, and providing organizational support. When reflecting these routines to the strategic MOT classifications presented in this study, there are similarities in business and technology environment scanning, strategy creation, road mapping, portfolio management, IPR management and feasibility analysis. Areas like project execution, technology transfer, technology adaptation and support, ideation and post project analysis, program selection, R&D funding and new product development, are differing. Technology needs assessment and product line planning routines are in the intersection of technology management and product or business management. The similarities and differences can be explained by the different view points taken to the subject in the frameworks i.e. some of the routines are in strategic management dimension, some are in operative management dimension. People talent and performance management would fit well into strategic management dimension, thus supplementing the framework presented in this study. The framework of Levin and Barnard would possibly benefit from provisioning additional views to the routines classification, according to operative and strategic dimensions.

Enterprises are not alike, but the importance of strategic MOT is uniformly similar in large and small companies. Conduct of technology management is a key for effective product development and it is critical for managing capabilities to apply technology on customer problems. Also management of the life-cycles of the products and technologies is mandatory for the companies, due to the long-term impacts that the investments in technologies have. Allegedly, all enterprises need to survive in the same changing environment with all the risks involved.

The inevitable need for strategic MOT has managerial implications to enterprises, especially on how to efficiently and effectively organize management of technology activities. Currently MOT, product management and product development are often diversely practised as embedded activities. Nevertheless, every company has their specific problem areas, depending on their business and the company life-stage, and they are struggling to formulate a comprehensive view and defining the scope of MOT. The need for explicit and systematic MOT practises become more evident as a company grows. Typically the formality of processes and practises increases as a company grows, but small to medium sized companies do not need similar management practises as large companies, and they do not have as many resources as large organizations (Desouza and Awazu, 2006; Savioz, 2006). Therefore, for them, MOT practises cannot be seen as a downscaled framework from large enterprises.

Consequently, we suggest that The An enterprise should look at MOT as an explicitly managed function. MOT has an interrelation to the other functions and management disciplines of an organization. MOT as a function needs to be developed and integrated with the other practises and processes of a company. Technology management as an own

functional management discipline is highlighted in Figure 8. Technology management should be considered as a strategic management activity, similar to strategy, business and product portfolio management. These disciplines involve “what” and “why” aspects of the company’s management to accomplish its mission and to satisfy its market and customer needs. From an MOT point of view, the key issues are which technologies to use and why, which technologies to research and acquire, when to introduce new technology, how much to invest and when, and which technology to refresh or retire. Accordingly, technological topics have to be managed throughout the entire lifecycles of the products and technologies. On the other hand, operative management disciplines focus on managing the “how” aspects of concrete research, technology creation product development projects. In this respect, strategic MOT has to be seen as a clearly distinguishing discipline.

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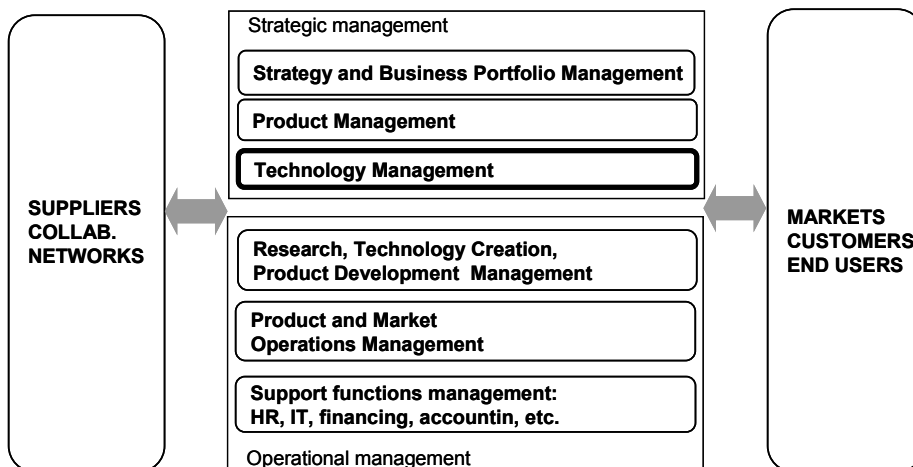


Figure 8:
Technology management as a distinctive strategic management function

For the development of MOT as a distinguishing discipline, the presented framework of strategic management of technology is suggested to give a frame of reference for practitioners to analyze problem fields of technology management. The main use of the framework is to provide structure to management dimensions and to present a logical order of relevant topics for self-reflection and dialog.

Obviously a company has to derive its objectives for technology from its corporate and business strategy, in order to make the desired impact based on systematic MOT. Accordingly, it has to create its structures for strategic MOT. For the MOT structures within design and development, the framework can be applied to give a frame of reference on what the elements are. The classified artefacts indicate what processes are needed for the creation of the artefacts. Each process involves appropriate methods, tools and IT systems. To run the processes a company needs organizational resources, governance structures, and managerial functions. Activities need to be integrated with the company’s other processes, and information management systems have to be built to support them.

All of the mentioned MOT practises involve specific skills and they need to be planned, organized, executed and monitored appropriately. This imposes extensive competence development and managerial challenges for the companies to improve their capabilities to manage technology for sustained business success.

5. Conclusions

In this paper, structures of strategic management of technology are introduced as elements in a conceptual framework. The results and findings in the study of high-tech small to medium-sized enterprises confirmed that the field of MOT is perceived as a complicated and confusing field among practitioners. MOT is seen important as a concept, but in reality, there is little evidence that practises are systematic or well integrated into the day to day operations of enterprises.

The elements of the framework are well recognized and evaluated to be important by practitioners. Based on abductive reasoning, incorporating theory matching with practical findings, the presented framework can be considered to have practical validity and relevance with respect to perceptions of the interviewed practitioners. All of the elements of the framework were not validated or did emerge through the interviews in this study. The entire framework has been elaborated, based on accumulated information from literature and practises of large and small to medium-sized enterprises. Thus the validity of the framework has been ensured by using different sources of information. The proposed conceptual framework represents our current explanation on what the elements of strategic management of technology are. The classification of the framework is not asserted to be exhaustive, and further amendments are desired by the scholars and practitioners.

As a whole, there is a lot of contingency in the concepts and practises of strategic management of technology. The need for systematic MOT practises in a company changes over time, depending on the life stage and size of the company. As a company matures and grows, management of technology practises can be assumed to develop accordingly. Therefore, a consistent framework with a logical order of elements in different management dimensions is needed to assist in analysis, self-reflection and dialog for systematic development of strategic MOT practises in enterprises.

This research did not intend to reveal how practises are implemented, or what their maturity, effectiveness and efficiency is. To investigate how the theoretical framework can be applied for the development of MOT, practises in enterprises would require in-depth case examples from different sizes of enterprises. Also the relationship of strategic MOT towards e.g., innovation management, knowledge management, learning and strategic capabilities, would further increase the clarity of the concepts in these fields.

The framework presented in this paper is suggested to provide premise for further theory development and to be applicable as a frame of reference for designing strategic MOT practises in enterprises. As a conclusion, we also propose that strategic MOT should be perceived and evolved in enterprises as a distinguishing function and management discipline, thus enhancing the management paradigm of multifunctional organizations.

In future research it would be very interesting to see how the elements are configured in different enterprises, what the practical challenges are, and how the elements can be horizontally and vertically integrated to gain an optimum outcome. Also, the entire

framework can be elaborated, and potentially new element groups could be found. Another area of research study area would be how strategic technology management practices are linked with key business processes. That is to investigate how to link technology management with business development, new product development, order-delivery processes or other main business processes.

Structures
of Strategic
Management
of Technology
in a Conceptual
Framework
of Enterprise
Practice

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Appendix 1

Qualitative questions of the interviews (to be left out from the final paper?)

1. What is management of technology (MOT) from your perspective?
2. How does your company ensure that the company has the best technologies available for its business purposes?
3. What kind of practises, methods and tools do you have for MOT activities?
4. What kind of documents and outcomes do you create as a result of MOT activity?
5. How do you make the planning and set objectives for the MOT activities?
6. How do you steer the MOT activities?
7. What kind of technology topics do you make decisions on? Examples?
8. Who or what bodies make the decisions? How often? How are the decisions linked to the company's other decision making?
9. What objectives regarding to technology have your defined in order to gain competitive advantages? Please describe some examples.
10. What MOT activities have the biggest impact to your company's competitive advantages?
11. What MOT activities need most improvement in your company?
12. What would be really new in management of technology (MOT) that would make a big impact on your company's success?

Appendix 2

Statements for evaluation in the interviews (to be left out from the final paper?)

Scale for evaluating the importance of the statement: 1= not important, 2= somewhat important, 3= quite important, 4= very important, 5= extremely important, NA = Not Applicable.

Scale for evaluating the current state of the statement: 1= not practised, 2= practised occasionally, 3= developing practise, 4= practicing, 5=well established practise, NA = Not Applicable.

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Statements for evaluation:

1. We create and maintain explicit technology strategy for our businesses.
2. We create and maintain technology forecasts for our key technologies.
3. We create and maintain technology maps and roadmaps for technologies.
4. We create and maintain a plan what technologies to study and research.
5. We create and maintain a plan what technologies to use in our products.
6. We create and maintain architecture roadmaps for our products.
7. We create and maintain internal technical guidelines and standards.
8. We do systematically technology scouting and intelligence.
9. We do systematically technology evaluation before technology selection.
10. We do systematically supplier and technology cost capability evaluation.
11. We do systematically decisions on selection and use of key technologies.
12. We do systematically technology development in advance.
13. We do systematically patent our discoveries and inventions.
14. We do systematically link our technology plans with our product plans.
15. We do systematically engage suppliers early in product concept phase.
16. We do systematically collaboration with other companies and institutes.
17. We do systematically life-cycle planning for product technologies.
18. We do systematically a disposal plan for our products for the end of life.