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# MANAGING THE FRONT END OF INNOVATION IN A NETWORKED COMPANY ENVIRONMENT – COMBINING STRATEGY, PROCESSES AND SYSTEMS OF INNOVATION

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**ABSTRACT**

Jouni Koivuniemi

**Managing the Front End of Innovation in a Networked Company Environment - Combining Strategy, Processes and Systems of Innovation**

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The objective of the thesis is to enhance the understanding about the management of the front end phases of the innovation process in a networked environment. The thesis approaches the front end of innovation from three perspectives, including the strategy, processes and systems of innovation. The purpose of the use of different perspectives in the thesis is that of providing an extensive systemic view of the front end, and uncovering the complex nature of innovation management. The context of the research is the networked operating environment of firms. The unit of analysis is the firm itself or its innovation processes, which means that this research approaches the innovation networks from the point of view of a firm.

The strategy perspective of the thesis emphasises the importance of purposeful innovation management, the innovation strategy of firms. The role of innovation processes is critical in carrying out innovation strategies in practice, supporting the development of organizational routines for innovation, and driving the strategic renewal of companies. The primary focus of the thesis from systems perspective is on idea management systems, which are defined as a part of innovation management systems, and defined for this thesis as any working combination of methodology and tools (manual or IT-supported) that enhance the management of innovations within their early phases.

The main contribution of the thesis are the managerial frameworks developed for managing the front end of innovation, which purposefully "wire" the front end of innovation into the strategy and business processes of a firm. The thesis contributes to modern innovation management by connecting the internal and external collaboration networks as foundational elements for successful management of the early phases of innovation processes in a dynamic environment. The innovation capability of a firm is largely defined by its ability to rely on and make use of internal and external collaboration already during the front end activities, which by definition include opportunity identification and analysis, idea generation, profileration and selection, and concept definition. More specifically, coordination of the interfaces between these activities, and between the internal and external innovation environments of a firm is emphasised. The role of information systems, in particular idea management systems, is to support and delineate the innovation-oriented behaviour and interaction of individuals and organizations during front end activities.

The findings and frameworks developed in the thesis can be used by companies for purposeful promotion of their front end processes. The thesis provides a systemic strategy framework for managing the front end of innovation – not as a separate process, but as an elemental bundle of

activities that is closely linked to the overall innovation process and strategy of a firm in a distributed environment. The theoretical contribution of the thesis relies on the advancement of the open innovation paradigm in the strategic context of a firm within its internal and external innovation environments.

This thesis applies the constructive research approach and case study methodology to provide theoretically significant results, which are also practically beneficial.

**Keywords:** innovation management, front end of innovation, R&D management, open innovation, innovation systems, innovation strategy, innovation process

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Every project has a start and an end. When I was presenting the firstly written paper of the dissertation at the PICMET conference in Oregon, I had a plaster in my ankle due to a broken Achilles tendon in my right foot. And now, after some years have gone and I'm writing these words, I have just got out of another plaster for the same reason in my left foot. I do not believe in destiny, but probably the last occasion was a horn blow for finally finishing this project.

I think the ultimate driver for me to take this fascinating dissertation project was the willingness to learn and understand. During this project I have had a great privilege to work with various talented people. I would like to thank you all equally and some persons in particular.

I want to thank my supervisor Professor Markku Tuominen for his guidance and patience in the project. He has also had a great impact in providing financial support for my research. During the project, I have worked in two extremely inspiring work communities. I started my post-graduate studies at the Department of Industrial Engineering and Management at LUT. I want to express my gratitude for the members of MOT team. We have enjoyed many times together the artifacts of academic and social life. The other community where I have worked is Technology Business Research Center at LUT. I would regard TBRC as a landmark among working environments. For this, I owe special thanks to Professor Kirsimarja Blomqvist, Professor Tuomo Kässi and Mrs. Päivi Nuutinen. I greatly appreciate my co-authors and research fellows for the cooperation in making research and writing the papers, in particular Petteri Piippo, Dr. Hannu Kärkkäinen, Jan Edelmann, Dr. Ville Ojanen, Dr. Kalle Elfvengren, and Matti Karvonen. Also, I want to thank all the people and companies, who have participated in the TOP, 5TT, InnoSpring, and Talikko projects.

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In a dissertation it is important to express what you want to say and what you mean to say. I appreciate Mrs. Sinikka Talonpoika and Ms. Minna Vierimaa for their professional help in editing the language of this dissertation. Although it is still difficult, thanks to you, my written english has advanced during the project.

In a busy world, it is balancing to understand your roots – what you are and where you come from. I want to thank my parents Aulikki and Pekka for their support and encouragement.

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Life is a continuous learning process, full of potential challenging projects. At the moment I do not even want to think about what the next one could be, but after a while … there will be a new one for me. Once again, thank you all for supporting me in my dissertation project.

Lappeenranta, November 2008

Jouni Koivuniemi

## TABLE OF CONTENTS

**PART I: SUMMARY OF THE DISSERTATION**

**1 INTRODUCTION ..... 1**

1.1 Macro-economical motives for innovation in Europe and in Finland ..... 1
1.2 Micro-economical motives and background for research ..... 3
1.3 Scope and objectives ..... 5
1.4 Positioning the thesis in the research of management of innovation ..... 7
1.5 Structure of the thesis ..... 8
1.6 Definition of key terms ..... 9

**2 MANAGEMENT OF INNOVATION IN THE NETWORKED COMPANY CONTEXT ..... 11**

2.1 Theories of competition and strategic perspective on innovation management ..... 11
2.2 Innovation management and innovative organizations ..... 12
2.3 Open innovation paradigm ..... 13
*2.3.1 Externally open innovation environment ..... 13*
*2.3.2 Internally open innovation environment ..... 14*
2.4 Framework for networked innovation management ..... 15

**3 THE FRONT END OF INNOVATION ..... 17**

3.1 Defining the front end of innovation ..... 17
3.2 Purposes of the front end of innovation ..... 18
3.3 Contents and critical sub-processes ..... 20
3.4 Inter-organizational innovation processes and the FEI ..... 23

**4 INNOVATION AND IDEA MANAGEMENT SYSTEMS ..... 26**

4.1 Systemic support for innovation management ..... 26
4.2 Knowledge management and innovation management systems ..... 26
4.3 Idea management systems ..... 28

**5 RESEARCH STRATEGY AND METHODOLOGY ..... 30**

5.1 Categorization of relevant qualitative research approaches ..... 30
5.2 Constructive research approach ..... 31
5.3 Case study research ..... 32
5.4 Criteria for judging qualitative research ..... 33

**6 SUMMARY OF PUBLICATIONS ..... 35**

6.1 Publication 1: Purpose of the product development process ..... 35
6.2 Publication 2: Towards networked R&D management ..... 38
6.3 Publication 3: Anatomy of the front end of innovation ..... 39
6.4 Publication 4: R&D project selection methods and systems in innovation management ..... 40
6.5 Publication 5: Intranet-based system for the product innovation management process ..... 42
6.6 Publication 6: A groupware tool for R&D project selection ..... 43
6.7 Publication 7: Toward internally and externally open front end of innovation ..... 44

**7 DISCUSSION AND CONCLUSIONS ..... 46**

7.1 Managerial contribution and implications ..... 46
7.2 Theoretical contribution and implications ..... 48
7.3 Validity and quality of the research ..... 48
7.4 Limitations of the thesis ..... 49
7.5 Suggestions for further research ..... 50

**8 REFERENCES ..... 51**

**APPENDICES**

**PART II: PUBLICATIONS**

**LIST OF PUBLICATIONS**[1]

1. Koivuniemi, J., Piippo, P. and Tuominen, M. (2000) *The Purpose of Product Development Process*. The R&D Management Conference, July 10-11, 2000, Manchester, U.K.

2. Blomqvist, K., Hara V., Koivuniemi, J. and Äijö, T. (2004) Towards Networked R&D Management: Sonera Corporation's R&D management in the Dynamic Environment as an Example. *R&D Management*, Vol. 34, No. 5, pp. 587-599.

3. Koivuniemi, J. (2004) *Anatomy of the Front End of Innovation: Contents, Shortcomings and Trends*. Published in the Proceedings (CD-ROM) of the PICMET Symposium 2004: Innovation Management in the Technology-Driven World, July 31 – August 4, 2004, Seoul, Korea.

4. Koivuniemi, J. and Edelmann, J. (2003) *R&D Project Selection Methods and Systems in Innovation Management: A Process Based Approach*. The 12th International Conference on Management of Technology, IAMOT 2003, May 13-15, 2003, Nancy, France.

5. Piippo, P., Koivuniemi, J., Kärkkäinen, H., Tuominen, M. and Ichimura T. (2003) Intranet Based System for Product Innovation Management Process. *International Journal of Technology Management*, Vol. 25, No 6/7, pp. 631-642.

6. Koivuniemi, J., Piippo, P., Kärkkäinen, H. and Tuominen, M. (1999) *A Groupware Tool for R&D Project Selection in Distributed Company Environment*. Published in the Proceedings of the PICMET Conference 1999 (CD-ROM): Technology & Innovation Management: Setting the Pace for the Third Millenium, July 25-29, 1999, Portland (OR), USA.

7. Koivuniemi, J., and Karvonen, M. (2008) Towards Internally and Externally Open Front End of Innovation: A Case Study from Pulp and Paper Industry. Published in the Research Reports series of the Technology Business Research Center at Lappeenranta University of Technology, 17. ISBN 978-952-214-690-8.

[1] Note: The publications are presented in a non-chronological order with a particular purpose as defined in Chapter 6.

**CONTRIBUTION OF THE AUTHOR IN THE PUBLICATIONS**

Publication 1
Planning of research: Participated in the research process as a researcher.
Data collection: Participated in the data collection. Carried out most of the literature study.
Analysis of results: Joint main responsibility in the analysis.
Writing the paper: Main author, responsible for the writing process. Wrote most of the paper.

Publication 2
Planning of research: Participated in the planning process of the paper.
Data collection: Carried out the part of literature study concerning R&D management.
Analysis of results: Participated in the analysis of the results.
Writing the paper: Wrote a part of the theoretical state-of-the-art and minor parts in other chapters.

Publication 3
Planning of research: Responsible for the planning of the research.
Data collection: Responsible for the data collection and analysis.
Analysis of results: Responsible for constructing the results and their analysis.
Writing the paper: Main author, responsible for the writing process. Wrote the paper.

Publication 4
Planning of research: Responsible for the planning of the research.
Data collection: Responsible for the literature study.
Analysis of results: Responsible for the construction of the results and analysis.
Writing the paper: Main author, wrote most of the paper.

Publication 5
Planning of research: Participated in the planning process of the research and the paper.
Data collection: Participated in the data collection and analysis.
Analysis of results: Participated in the construction of results. Responsible for the visual design.
Writing the paper: Wrote a part of the theoretical state-of-the-art and participated in other chapters.

Publication 6
Planning of research: Responsible for the research process and planning.
Data collection: Responsible for the data collection.
Analysis of results: Responsible for constructing the results and analysis.
Writing the paper: Main author, wrote most of the paper.

Publication 7
Planning of research: Responsible for the research process and planning.
Data collection: Responsible for the data collection.
Analysis of results: Responsible for constructing the results and analysis.
Writing the paper: Main author, wrote most of the paper.

## LIST OF FIGURES

Figure 1. Summary Innovation Index 2007 and average growth rates 2003-2007. ..... 1
Figure 2. EU innovation gap towards the USA and Japan. ..... 2
Figure 3. Focus of the research. ..... 6
Figure 4. Logical dependency structure of the research perspectives and focus. ..... 6
Figure 5. Structure of the thesis. ..... 9
Figure 6. Open innovation as a bi-directional exchange mechanism of innovations. ..... 13
Figure 7. Closed and open model of innovation. ..... 14
Figure 8. A framework for networked innovation management. ..... 16
Figure 9. The phases of the front end of innovation in recent studies. ..... 17
Figure 10. Sources of ideas, idea channels and idea markets. ..... 18
Figure 11. Cross-border front end of innovation. ..... 21
Figure 12. Inter-organizational front end framework. ..... 24
Figure 13. Disciplines of knowledge management. ..... 27
Figure 14. Constructive research approach in relation to other resarch approaches ..... 30
Figure 15. Constructive research approach. ..... 31
Figure 16. Content and results-based interdependencies between the publications. ..... 35

## LIST OF TABLES

Table 1. Theories of competition and types of innovation. ..... 11
Table 2. Two different innovation management archetypes. ..... 12
Table 3. Use of information technology in the front end of innovation. ..... 28
Table 4. Research approaches in industrial economics. ..... 31
Table 5. Process of building theories from case study research. ..... 33
Table 6. Summary of the objectives, data, methods and contribution of the publications. ..... 37

## LIST OF APPENDICES

Appendix 1. Developed process model for R&D project selection
Appendix 2. Case study – Drivers of structural changes in pulp and paper industry

## ABBREVIATIONS

| | |
|---|---|
| AHP | Analytic Hierarchy Process |
| EIS | European Innovation Scoreboard |
| FEI | Front end of innovation |
| FFE | Fuzzy front end |
| ICT | Information and communication technology |
| IT | Information technology |
| IO | Industrial organization |
| LUT | Lappeenranta University of Technology |
| NACE | Nomenclature Generale des Activities Economiques dans L`Union Europeenne<br>European industry standard classification system |
| NAICS | North American Industry Classification System |
| NPD | New product development |

| | |
|---|---|
| PDP | Product development process |
| PIM | Product innovation management |
| PPI | Pulp and paper industry |
| R&D | Research and development |
| SII | Summary innovation index |
| SIC | Standard industrial classification |
| SIM | Systems innovation management |
| WEF | World Economic Forum |

# PART I: SUMMARY OF THE DISSERTATION

# 1 INTRODUCTION

## 1.1 Macro-economical motives for innovation in Europe and in Finland

Innovations are the driving force of the competitiveness, growth and renewal of firms and nations. A significant source of innovation performance measures is provided by the European Innovation Scoreboard (EIS[2]) initiated by the European Commission (European Commission 2007). EIS measures innovation performance across the European Union, and in comparison to innovation performance in the USA and Japan, through five categories of measures:

- *Innovation drivers* measure the structural conditions required for innovation potential,
- *Knowledge creation* measures the investments in R&D activities,
- *Innovation & entrepreneurship* measures the efforts towards innovation at the firm level,
- *Application* measures the performance expressed in terms of labour and business activities and their value added in innovative sectors, and
- *Intellectual property* measures the achieved results in terms of successful know-how.

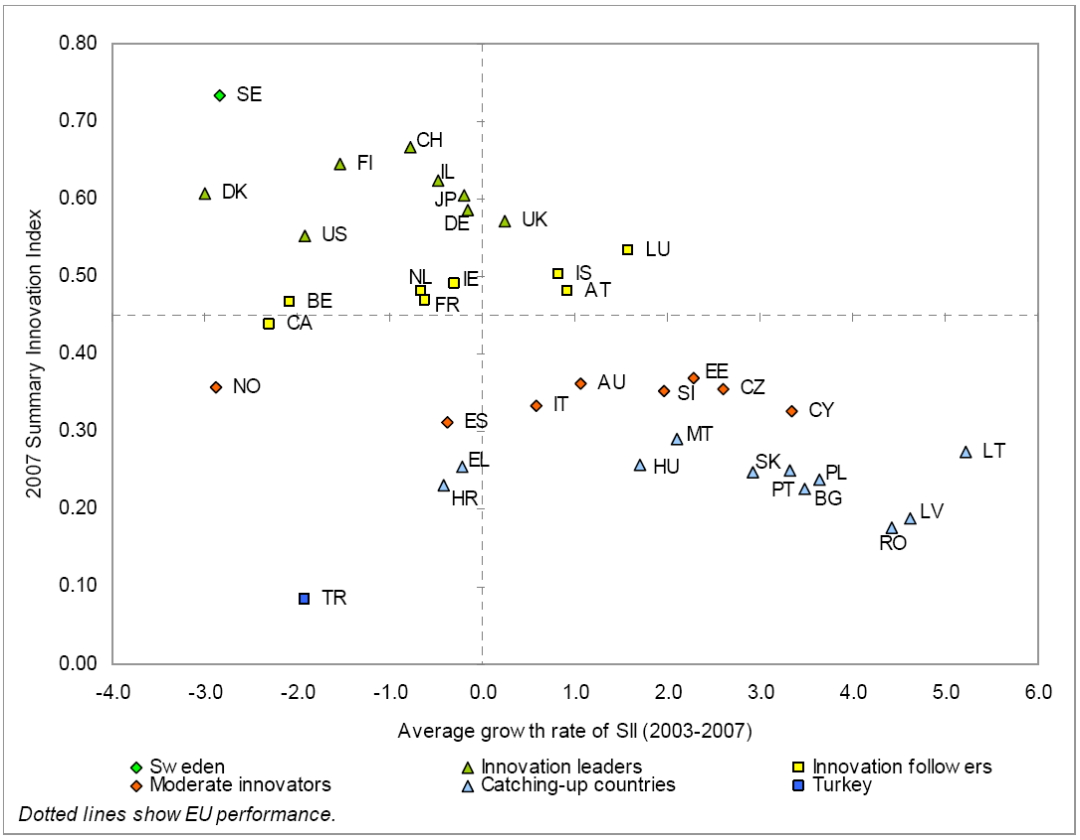


**Figure 1. Summary Innovation Index 2007 and average growth rates 2003-2007 (European Commission 2007).**

[2] An annual European Innovation Scoreboard has been produced since 2001, providing a reference point for innovation policy makers and analysts across Europe.

Figure 1 presents the results of the Summary Innovation Index based on the above categories of measures in the European countries. As can be seen, Finland belongs to the group of leading countries[3], and also scores a bit higher than the USA and Japan. When the analysis of innovation performance is carried out at the level of industrial sectors based on NACE[4] categorization, Finland is the European innovation leader in 10 industries out of the reported 24, and scores second in 6 industries (European Communities 2006).

Even if the results might look very good, at least from the Finnish national point of view, some critical issues need to be emphasised. As can be seen in Figure 2, Europe as a whole is still lagging[5] behind Japan and the USA in innovation performance. The gap towards the USA has been constantly decreasing, as is the case slightly also with Japan.

Several national issues in the Finnish environment need to be noted:

- sustaining a leading position is a difficult task due to intensified global competition;
- due to stronger global networking the absolute innovation performance measures are not significant as such, but competitiveness is always a relative and changing issue. For this reason the fundamental drivers of competitiveness such as innovation need to be focused;
- several traditionally strong industries in Finland are facing major challenges (e.g. the forest industry due to globalization and the ICT industry due to lowered profit margins in the current mainstream business);
- there is a growing need to change the scope of innovations as the major industries are in transformation (e.g. new investments abroad)

The main argument of the above illustration of relative innovation performances is that while the leading European countries score high in the current innovation performance measures, the mechanisms of innovation need to be continuously advanced at national and at firm level to sustain the leading position. For smaller economies, like Finland, innovation and knowledge-based competition are expected to be the most powerful means of success in the future. In this thesis, the firm level mechanisms for innovation are in focus.

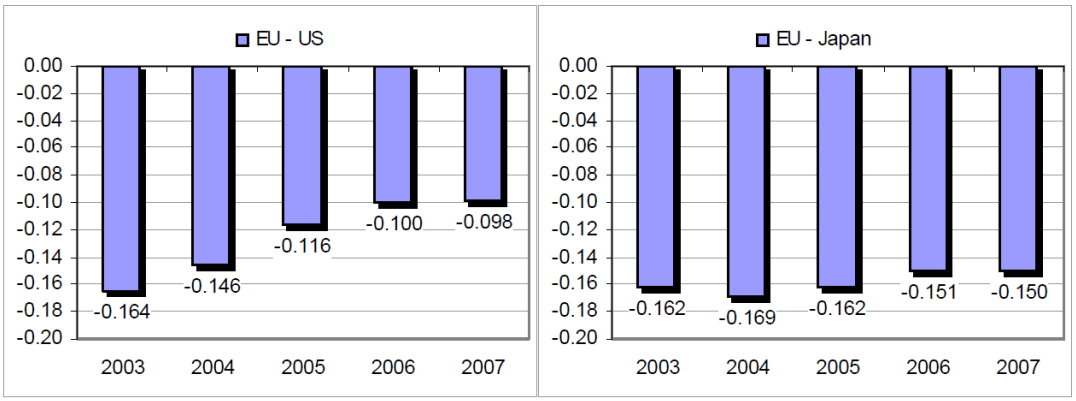


**Figure 2. EU innovation gap towards the USA and Japan (European Commission 2007).**

[3] Also, the Global Competitiveness Report (WEF) and The World Competitiveness Yearbook (IMD, International Institute for Management Development) place Finland in the very top in the world statistics.

[4] NACE is the European industry standard classification system. NACE is equivalent to the SIC and NAICS systems.

[5] The whole point of the Lisbon strategy is to increase the competitiveness and innovation of Europe.

## 1.2 Micro-economical motives and background for research

Micro-economics considers the behaviour of individual firms, which in the context of this thesis means the mechanisms the firms use to govern innovation. Firms' competitiveness and renewal are largely defined by their capability to continuously generate and absorb innovations (Christensen 1997, Hamel 2000, Lawson and Samson 2001, Miller and Morris 1999, Tidd et al. 2005, Tushman and O'Reilly 1997). Innovation management is a strategic issue (Tidd et al. 2005) and a procedural issue, i.e. how to manage the process from embryonic ideas into successful innovations (Cooper 1988, Cooper 1993, Cooper 1999).

Innovation management is also a complex process of managing information and knowledge flows inside the organization and in inter-organizational interfaces (Macdonald 1998, Nonaka and Teece 2001). Innovation management can be viewed as a system involving input information and knowledge from critical sources, a system or set of activities that process the information and the output determining the desired solutions the system is to provide (Tuominen et al. 1997). The critical areas of input information include the customers' needs, the competitive situation, the company's goals and strategies, the company's resources and technological opportunities, and environmental and legislative requirements. A fundamental source of signals of changes is the competitive environment of firms (Barney 1986, McGahan 2004). The innovation process can be seen as a cross-functional and cross-organizational process, where new information technology-based tools and systems enable effective information management. In organizations it is a continuous challenge to select the most effective and innovation friendly tools and methods for use.

Focusing on the early phases of the innovation process, the fuzzy front end can be regarded as the source of all business value creation (Matheson and Matheson 1998). Several authors regard the front end of innovation as one of the greatest opportunities for improvement of the overall innovation process (see e.g. Cooper 1993, Koen et al. 2002). Cooper's (1993) studies show the upfront homework to be one of the most critical success factors[6] in new product development. This view is supported in many studies (e.g. Cooper and Kleinschmidt 1994, Wheelwright and Clark 1992). Lawson and Samson (2001) suggest that innovation management can be viewed as a form of organizational capability. They continue by saying that excellent companies invest in and nurture this capability, from which they execute effective innovation processes, leading to innovations in new products, services and processes, and superior business performance results.

Organizations focus on the front end activities in order to increase the value, amount and probability of success of high potential concepts entering development. High performance companies in new product development spend 44 per cent of their total development time on their front end activities, whereas the figure for low performing companies is 22 per cent (Paul 2002).

In a Delphi study among practitioners and academic researchers, Scott (2000) (see also Scott 1998) has identified critical activities of management of technology as being in greatest need of improvement in many high-tech companies. The number two issue in the list of these activities is 'new product project selection', an activity (or series of different activities) that forms an extensive part of those actions needed to be taken during the front end of innovation. According to Scott (2000), 'new product project selection' involves such issues as the criteria to be used, how to

[6] An extensive study on the success factors in new product development is provided by Ernst (2002).

establish a systematic approach to selection, and inability of conventional financial analysis criteria to evaluate the potential of radical new technology.

The front end of innovation clearly seems to be an area for development in firms – it is a strategically essential area for improvement and includes the seeds of competitiveness through innovation. The emergence of collaboration and other forms of networking require the development of more holistic views of firm level innovation management. This development influences all the phases of the innovation process, and requires the mechanisms for inter-firm cooperation and collaboration to be included already in the front end phases of the innovation process. The network in this context can be understood as a network between different sub-units inside an organization (cross-functional context) or a network between different organizations (cross-organizational context).

The main motives for the thesis can be presented as follows:

From innovation strategy point of view
- the front end of innovation is gaining strategic importance in firms and in academia
- mainstream business needs to be combined with new stream innovations (Miller and Morris 1999, Lawson and Samson 2001)
- networking (incl. cooperative and collaborative arrangements between firms) and information and knowledge sharing are emphasised (Blomqvist et al. 2003, Cohen and Levinthal 1990, Combs 1993; Harmsen et al. 2000, Ingham and Mothe 1998, Sawhney and Prandelli 2000)
- innovation is becoming an organization-wide issue (Miles et al. 2000)
- innovation processes are becoming more open to external sources of ideas and innovations (Chesbrough 2003)

From innovation process point of view
- the balance between systematics and flexibility in R&D and innovation processes is difficult to manage (MacCormack et al. 2001) – this issue is extremely pivotal during the front end
- part-whole relationships in innovation processes are difficult to manage (Van de Ven 1986)
- different types of innovation processes are required for different types of innovations

From innovation systems and methods point of view
- methods and tools are often difficult to use (Piippo et al. 2002)
- methods and tools should provide support over the activities in the innovation process (Piippo et al. 2003)
- electronification of the whole innovation process is on the way (Rothwell 1994)
- the open innovation paradigm has an effect on the innovation systems and methods.

The results presented in the dissertation are based on the research carried out in three applied research projects funded by the Finnish Funding Agency for Technology and Innovation and Finnish industry (altogether 12 firms have participated in these projects). The research projects include: TOP – The Strategic Aiming and Assessment of Product Development (1996-1999), 5TT – Product Development Management in the Networked Economy (2000-2004), InnoSpring – Collaborative Innovation: Culture, Networks, Architecture, Pilots and Metrics (2005), and Talikko – Business Creation with New Concepts in the Intersection of Industries: Electricity Networks and Generation, ICT and Forest Industries (2006-2008). The TOP project was coordinated by the Department of Industrial Engineering and Management at Lappeenranta University of Technology.

The 5TT, InnoSpring and Talikko projects were coordinated by the Technology Business Research Center at Lappeenranta University of Technology.

### 1.3 Scope and objectives

The focus for this thesis is in the intersection of three essential perspectives of innovation and R&D management, as presented in Figure 3, including the strategic perspective, process perspective and systems perspective. While each of these dimensions includes specific research challenges and problems, they have been selected as the research domains for this dissertation to provide a rich view of the pivotal dimensions of the management of the front end of innovation. The concentric circles presented in Figure 3 describe the layered focus of the dissertation towards the front end of innovation. The purpose of integrating the three approaches is to form a systemic view of the front end of innovation in the networked business environment.

*Strategic perspective:* The logic behind the strategy perspective is based on the understanding that innovation processes need to be linked to the strategic management of companies, due to their ability to accomplish companies' present strategies and drive the strategic renewal of companies. The primary focus of the thesis from the strategic perspective is the management of innovation in the organizational context (innovation strategy). This thesis applies a hierarchic view of firm level strategies (see e.g. Danila 1989), according to which the innovation strategy is subordinate to the business strategy. The innovation strategy is regarded as a fundamental part of strategic management, because the competition of firms is strongly based on or influenced by new innovations.

*Process perspective:* The reason for focusing on the process perspective lies behind the paradigm of systematics and process management, which entails that the innovation activities need to be managed and carried out systematically[7]. The primary focus of the thesis from the process perspective is the front end of innovation. The management of innovation and product development in companies is often described in the form of a process with sequential and parallel activities. Companies' business activities are formed from several interacting key business processes, where the innovation process is one of the most challenging ones. The front end of innovation constitutes a part of the innovation process, namely its critical early phases before the actual realization of projects (product development phase).

*Systems perspective:* An appropriate system and methodological support is needed in order to carry out innovation related activities in practice. The primary focus of the thesis from the systems perspective is on the idea management systems, which can be defined as any combination of methodology and tools (manual or IT supported) that enhance the management of innovations in their early phases. Idea management systems are seen as a part of innovation management systems, which in turn are viewed as a part of strategic management systems in firms.

[7] It should be noted that the concept of systematic innovation management represents a school of thought according to which innovation can be managed. The author of the dissertation supports this view. The same applies to the view that the causal relationships between the means and ends of innovation management can hardly be expressed explicitly.

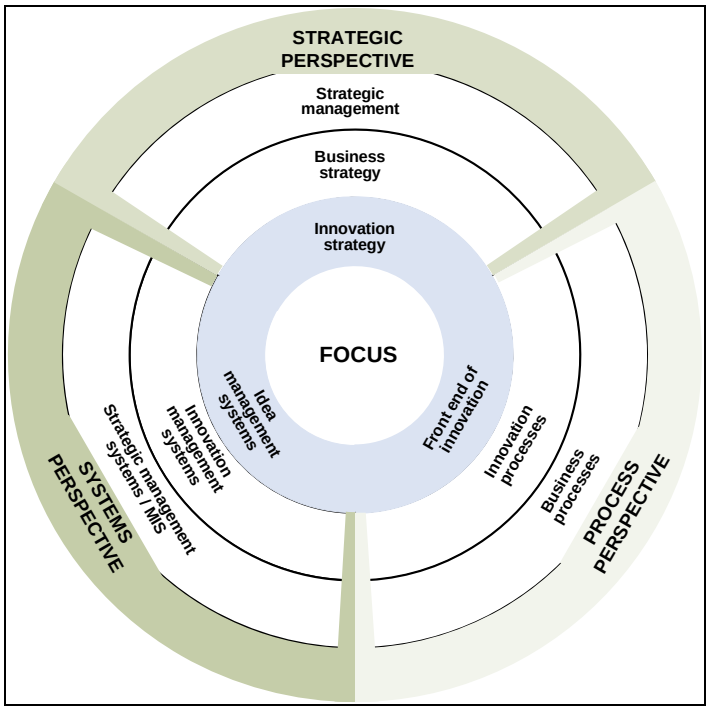


**Figure 3. Focus of the research.**

The research perspectives of the thesis form a logical dependency structure, as presented in Figure 4. The context for the whole thesis is the networked operating environment of firms. The unit of analysis is the firm itself or its innovation processes, i.e. this thesis approaches the innovation networks from the point of view of a firm. A firm realizes its strategies, including the innovation strategy, in the industrial and economic context (business ecosystem, industry, market area).

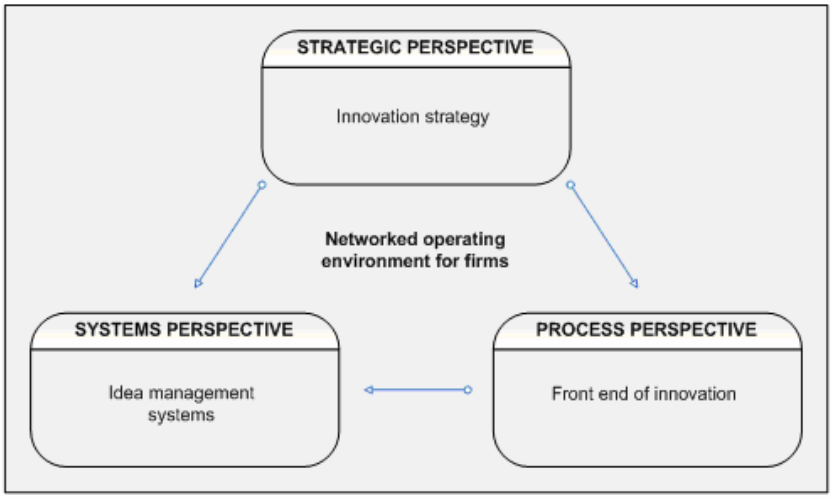


**Figure 4. Logical dependency structure of the research perspectives and focus.**

The innovation processes are defined and designed on the basis of strategic choices related to a firm's present strategy or intended new strategy. The systems, methods and tools follow the priorities of the innovation processes and strategy.

**The main objective of the thesis is to enhance the understanding about the management of the front end phases of the innovation process in a networked environment by combining the strategy, process and systems perspectives of innovation.** The focus of the thesis is on the processes and activities that are needed to govern the front end of innovation in the networked business environment. From the strategic perspective the purpose is to study and link the front end of innovation to the strategic management and decision making in organizations. From the systems perspective, applicable methods and IT systems related to the front end of innovation are in focus.

The following research questions have been defined for the thesis:

*Research question 1:* How are the purposes of R&D and innovation processes and innovation strategy linked in the context of a firm?
*Research question 2:* How is the systemic framework for the front end of innovation formed in the networked operating environment of firms?
*Research question 3:* How to provide innovation processes with appropriate systems support to promote the use of innovation management processes in firms?

The individual publications in Part II aim to answer these research questions.

### 1.4 Positioning the thesis in the research of management of innovation

R&D management and innovation management are broad topics, and they incorporate many streams of research. For this reason it is appropriate to position the research in the field of innovation and R&D management studies.

According to Brown and Eisenhardt (1995), who refer to Adler (1989), innovation research can be divided into two broad areas of inquiry, which include the economics-oriented tradition and the organization-oriented tradition. The first one examines differences in the patterns of innovation across countries and industrial sectors[8]. In this area of inquiry, the actual process of product development is still largely a "black box" (Brown and Eisenhardt 1995). The organization-oriented research opens that black box by providing depth and rich understanding how actual products are developed within firms, a critical core capability for many firms. Brown and Eisenhardt (1995) conclude that the product development branch of research remains essential for a complete picture of innovation.

From the perspective of problems in the management of innovation, we can refer to Van de Ven (1986), who defines four problem domains for management of innovation:

- *The human problem of managing attention*, according to which people and their organizations are largely designed to focus on existing practices rather than pay attention to developing new ideas.
- *The process problem in managing ideas into good currency* so that innovative ideas are implemented and institutionalized. Innovation is a collective achievement of pushing ideas into innovations, where social and political dynamics of innovation become paramount.

[8] The sub-chapter on macro-economical motives on innovation is an example of this stream of literature.

- *The structural problem of managing part-whole relationships*, which emerges from the proliferation of ideas, people, and transactions as an innovation develops over time. A common characteristic of the innovation process is that multiple functions, resources, and disciplines are needed to transform an innovative idea into a concrete reality.
- *The strategic problem of institutional leadership*, which is one of creating an infrastructure that is conducive to innovation. Innovations not only adapt to existing organizational and industrial arrangements, they also transform the structure and practices of these environments.

An innovation literature categorization by Johannessen et al. (2001) defines four categories of innovation research:

- *Individual-oriented approach*, which emphasises the role of individual factors such as age, educational level, gender, cognitive style and creativity.
- *Structure-oriented approach*, which focuses on organizational characteristics, i.e. how organizational structure constrains or propels innovation (Slappendel 1996).
- *Interactive-oriented approach*, which focuses on how action influences structure, and vice versa in the innovation process (e.g. Van de Ven et al. 1989).
- *Systems of innovation-oriented approach*, which focuses on how national and regional innovation systems influence innovation activity in firms (e.g. Nelson and Winter 1982).

In the light of the above mentioned categorizations of innovation management research and literature, this thesis represents an organization-oriented approach (referring to Brown and Eisenhardt 1995), aiming at solving structural and strategic problems of innovation management (referring to Van de Van 1986) in the context of the front end of innovation, and fits mostly into the interactive-oriented approach (referring to Johannessen et al. 2001) as regards the analysis of the effects of a competitive environment on the development needs of innovation processes.

## 1.5 Structure of the thesis

Following the commonly practiced research tradition in the Department of Industrial Engineering and Management at LUT, the thesis is divided into two parts (see Figure 5): Part I – Introduction, and Part II – Publications. The purpose of Part I is to give an overview of the research area, describe relevant methodological aspects, summarize the results of publications, and present the overall contribution of the dissertation. In the case of this particular thesis, Part I also complements the research contribution with relevant new material, which was not available when the individual publications were written.

Part II of the thesis consists of seven (7) individual publications, which represent the research perspectives of the thesis, as shown in Figure 5. A more insightful content-based interdependency structure between the publications is given in Chapter 6, which summarizes the role and contribution of each of the publications in the thesis. All the publications have been written in collaboration with research colleagues, except Publication 3, which has been written solely by the author of the present thesis. The summary of the roles of the author in the publications was given in the beginning of this thesis. The author of the thesis has been the lead author in five publications, the second author in one publication, and the third author in one publication.

Modern research and writing of scientific publications is team work, and joint publications are regarded as highly valuable in providing complementary experience and competencies, leading to richness of analysis and increased quality of publications. Particularly in studies on innovation,

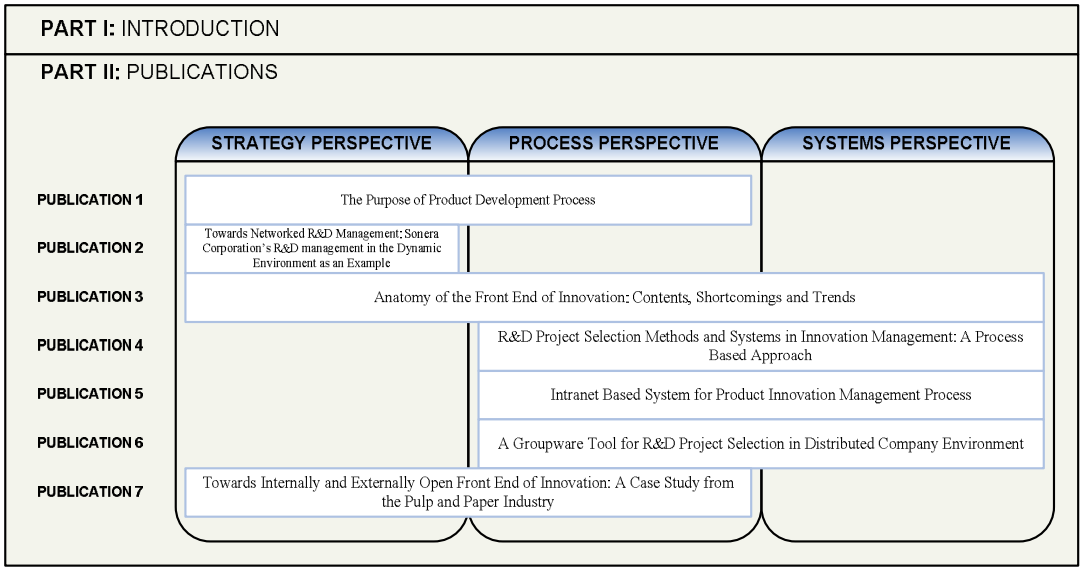


**Figure 5. Structure of the thesis.**

which have a strong social connotation in general, joint writing over inter-disciplinary fields of science should be encouraged.

### 1.6 Definition of key terms

A number of pivotal key terms are used in the thesis, which need to be defined. There are many different definitions for the terms in the innovation literature. The most useful and appropriate definitions for the purposes of the thesis are presented according to literature sources. In the publications, the basic definitions may have been altered and tuned to the different connotations of the terms.

**Innovation management –** Following the random and largely unpredictable nature of innovation, Tidd et al. (2005) define innovation management in the sense of creating conditions within an organization, in which a successful resolution of multiple challenges under high levels of uncertainty is made more likely. In other words, innovation management is about creating effective routines to support the innovation-oriented behaviour of organizations. Innovation is a management question, as there are choices to be made about resources and their disposition and coordination.

**Innovation process** – A pivotal part of the innovation management routines at the firm level is defined in the firm's innovation process. Innovation is a process of turning opportunities into new ideas and of putting these into widely used practice (Tidd et al. 2005). The innovation process constitutes of all types of innovation (incremental, radical, product, process etc.). In contrast to the product development process, the innovation process is often defined as a broader-reaching activity, which also includes actions in supporting the commercial exploitation of the outputs of the process. Koen et al. (2001) divide the innovation process into three parts: fuzzy front end (FFE), new product development (NPD), and commercialization.

**Product development process** – A disciplined and defined set of tasks and steps which describe the normal means by which a company repetitively converts embryonic ideas into salable products

or services (Belliveau et al. 2002). In contrast to the innovation process, the product development process focuses on product or service innovation.

**Front end of innovation (FEI)** – Often used similarly to the fuzzy front end, which is defined by Belliveau et al. (2002) as the messy "getting started" period of product development processes following the formation of a germ of an idea, but before the firm begins development (see also the definition for the innovation process above). The front end of innovation is often described to include the following iteratively carried-out activities: opportunity identification and analysis, idea genesis, idea selection, and concept and technology development.

**Networked R&D management** – A modern R&D management approach that emphasizes internal and external collaboration networks as critical for companies operating in a dynamic business environment, and defines collaboration as a meta-capability for innovation (for details, see Publication 2).

**Networked innovation management** – A managerial framework for supporting strategic management of innovation at the firm level. The framework integrates the concepts of competition, ideas of the dynamic capability view of the firm, open innovation, and networked R&D management. It "wires" the firm's internal innovation environment with its external innovation environment in four dimensions, including the strategy, markets, technology and organizational capabilities. In the heart of the framework is the innovation capability of the firm, which is defined by its ability to integrate and process the information on the defined dimensions (for details of the framework see Koivuniemi and Edelmann (2007) and Chapters 2&3 in the thesis).

**Innovation management system** – Any working combination of methods, tools (manual and computerized) and software that are used to support the activities in the innovation process.

**Idea management system** – Any working combination of methods, tools (manual and computerized) and software that are used to support the activities during the front end of innovation.

# 2 MANAGEMENT OF INNOVATION IN THE NETWORKED COMPANY CONTEXT

## 2.1 Theories of competition and strategic perspective on innovation management

Competition in its different forms drives innovation and strategy from outside a firm. The concept of competition has been studied widely in earlier microeconomic research, and it has been the basis for the development of normative theories of strategy.

An integrated analysis of the concept of competition defines three types of competition, which require different types of strategies (Barney 1986, 792):

- In the *industrial organization* (IO) competition "returns to firms are determined by the structure of the industry within which a firm finds itself". In this type of competition, the industry structure and positioning of the firm drive its strategy.
- *Chamberlinian competition* focuses on the unique assets and capabilities of individual firms, which affect the strategies firms can pursue as well as the returns to those strategies.
- *Schumpeterian view of competition* anticipates continuous change, which is driven by revolutionary innovations in products, markets and technologies. This is often referred to as "creative destruction" (Schumpeter 1934), where new radical innovations emerge, often outside the particular industry. Schumpeterian competition creates a continuum of technological and market uncertainties.

The integrated theories of strategy are important, because most firms, at any given point in time, face both IO and Chamberlinian competition and live under the constant threat of either Schumpeterian shocks or revolutions (Barney 1986). According to Hoskisson et al. (1999) the nature of strategy problems cannot easily be framed within a fixed paradigm. This is because the strategic management is necessarily a multi-paradigmatic discipline, requiring varied theoretical perspectives and methodologies. The more recent theories of a firm and strategy, such as core competence thinking (Prahalad and Hamel 1990) and the dynamic capability view of the firm (Teece et al. 1997) belong to the continuum of the theories of competition and strategy.

The competitive advantage of industrial organizations is nowadays based first on the understanding which type of competition the firm is involved in, and then on the use of various competitive strategies in an integrative manner (Barney 1986). The competitive environment and strategy of innovation defines the primary types of innovations (see Table 1).

**Table 1. Theories of competition and types of innovation.**

| | *Industrial organization competition* | *Chamberlinian competition* | *Schumpeterian competition* |
|---|---|---|---|
| *Source of competitiveness* | A firm's position in the industry defines its competitiveness | A firm has unique internal capabilities, which can be used for competitive advantage. | Radical new innovations create shocks for industries |
| *Focus of innovation strategy* | Cost cutting, economics of scale and scope | Knowledge-based competition; capability development | Innovation leadership |
| *Primary types of innovations (not exclusive)* | Process improvements; Process innovations; Product and service innovations | Organizational innovations; New business models | Radical innovations |

Source: Theories of competition and their definitions, adapted from Barney (1986).

## 2.2 Innovation management and innovative organizations

The goal of innovation management is to trigger, generate, control, and steer new ideas through an organization and to bring the outcome to the market (IEBM 2002). Tidd et al. (2005) present two archetypes of innovation management, as presented in Table 2.

**Table 2. Two different innovation management archetypes (adapted from Tidd et al. 2005).**

| | *Steady state archetype* | *Discontinuous innovation archetype* |
|---|---|---|
| *Interpretive schema – how the organization sees and makes sense of the world* | § There is an established set of rules of the game by which other competitors also play<br>§ Strategic direction is highly path-dependent | § No clear rules of the game – these emerge over time but cannot be predicted in advance<br>§ Strategic direction is highly path-independent |
| *Strategic decision-making* | § Makes use of decision-making processes which allocate resources on the basis of risk management linked to the above rules of the game<br>§ Controlled risks are taken<br>§ Political coalitions are significant influences maintaining the current trajectory | § High-level risk taking because of no clear trajectories – emphasis on fast and lightweight decisions rather than heavy commitment in initial stages<br>§ Multiple parallel bets, fast failure and learning as dominant themes.<br>§ High tolerance of failure but risk is managed by limited commitment<br>§ Entrepreneurial behaviour |
| *Operating routines* | § Operates with a set of routines and structures/procedures<br>§ Stage gate monitoring and review<br>§ Search behaviour happens along defined trajectories and uses tools and techniques for R&D, etc. which assume a known space to be explored – search and selection environment<br>§ Network building to support innovation – e.g. user involvement, supplier partnership, etc. – is done on the basis of developing close and strong ties | § Operating routines are open-ended, based on managing emergence<br>§ Project implementation is about the fuzzy front end, light touch strategic review and parallel experimentation<br>§ Probe and learn<br>§ Search behaviour is about peripheral vision, picking up early warning through weak signals of emerging trends<br>§ Linkages with heterogeneous population and less emphasis on established relationships than on weak ties |

While innovation management is increasing in importance from the perspective of the strategic management of a firm, also the features of innovative organizations become apparent. Innovative organizations are problem solving and capacity building-orientated, and can be characterized by the following (IEBM 2002):

- § Dissatisfaction with the existing state of affairs and an emphasis on constant improvement
- § Adaptive organizational structures and operational procedures
- § Imaginative management, receptivity to novel ideas
- § Eclecticism, integration, cross-fertilization of ideas and methods of work
- § Development of personal and team problem-solving skills
- § Emphasis on experimentation, exploration and continuous learning
- § Support for alternative problem-solving methodologies and alternative decision making models.

Innovation management at the firm level integrates strategic and operative level activities. The issue is examined e.g. by Poskela (2007) in the context of the front end of innovation. The results show that the effectiveness of integration of strategic and operative level front-end activities is dependent on the level of concreteness of the defined business strategies, the amount of business-minded decision making, and the balance between control and creativity.

## 2.3 Open innovation paradigm

Chesbrough (2003) has proposed a new paradigm to leverage the external stakeholders and knowledge seamlessly along with the innovation process. The open innovation paradigm expects firms' innovation systems to become more open to external sources of knowledge and resources in the future (see Figure 6), enabling effective import and export of innovations and knowledge in any phase of the innovation chain. Traditional innovation processes have focused mainly on the internal value chain for innovations through internal cooperation (cross-functional; cross-business unit) and opportunistic use of external resources. Open innovation uses bi-directional exchange mechanisms of ideas, innovations, technologies and knowledge in external interfaces (customers, suppliers, partners, research institutes, competitors). As such issues as NIH (not-invented-here) and other barriers of a firm's internal cooperation are concerned, open innovation can be expanded to include also internally open innovation. The focus in internally open innovation is in the interfaces between a firm's functions and business units.

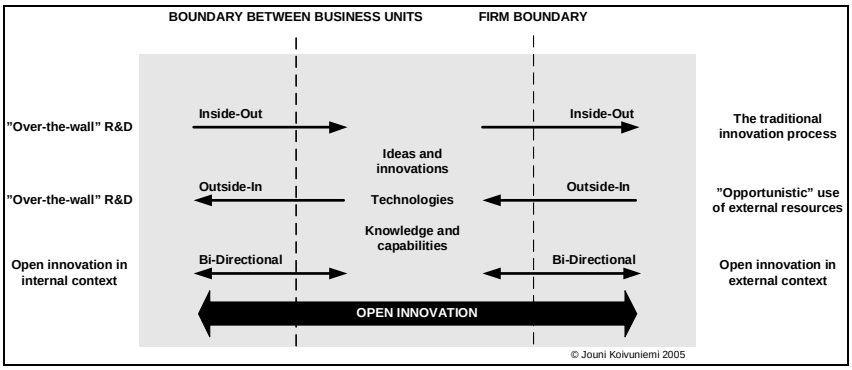


**Figure 6. Open innovation as a bi-directional exchange mechanism of innovations.**

### *2.3.1 Externally open innovation environment*

Figure 7 presents the transition from the closed innovation model to the open innovation model (Chesbrough 2003). When a firm attempts to leverage the external ideas and innovations more effectively in the open model, fundamental changes in the innovation processes and mental models of innovation management are needed. Companies need to alter their usual metrics for innovation management as well (Chesbrough 2004).

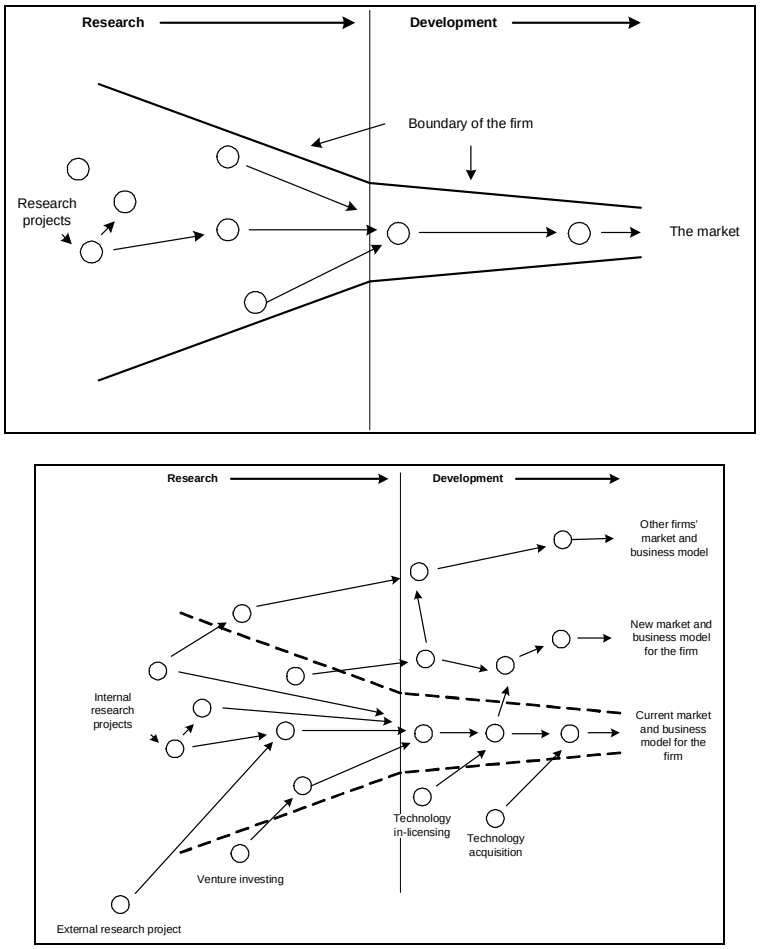


**Figure 7. Closed and open model of innovation (adapted from Chesbrough 2003).**

The main implication of the externally open front end of innovation is that a firm needs to open up interfaces for external sources of ideas. This means not only gathering new ideas from outside, but actively seeking business opportunities to those ideas that might be beneficial to external partners, but not in the focus of the particular firm. The key issue is the bi-directional nature of knowledge channels, and supportive mechanisms. A closer integration of innovation-critical processes over organizational boundaries is anticipated through open innovation.

### *2.3.2 Internally open innovation environment*

The focus of internally open innovation is in the interfaces between a firm's functions and business units to support a fluent flow of ideas. In some cases, the internal barriers for innovation might be even more decisive than external barriers. This is particularly the case with radical innovations, due to established routines and strategies. More specifically, we can define internally open innovation to include the following aspects:

- *Structural openness:* Lean structures and organization for innovation to enable seamless transfer of ideas within and across business units
- *Process openness:* Appropriate operation models and processes for innovation to support the balance between control and freedom and flexibility, and channelling of ideas and innovations across and within innovation processes
- *Systems openness:* Interoperable information systems for innovation to support idea management and effective flow and convergence of knowledge
- *Cultural openness:* Participatory and active internal culture for innovation that seeks new opportunities, make use of opportunities and uses innovation for self-renewal

The main implication of practicing internally open innovation during the front end of innovation is the development of new kind of mechanisms for a more open flow of information and ideas across organizational units and processes. It would also mean the establishment of a multi-channel model for innovation, both in the gathering of ideas and in proliferating and evaluating them.

## 2.4 Framework for networked innovation management[9]

Drawing on the strategic view of innovation and open innovation paradigm, we can construct a framework for networked innovation management, which includes the following elements: two main axes, innovation capability as the heart of the model, the firm's internal innovation environment, the firm's external innovation environment, and four dimensions (strategy, markets, technology and organizational capabilities). More specifically, the two axes include:

- The market axis, which comprises the technology dimension (hardware for innovation, including internal and external technologies for the firm) and the market dimension (internal and external markets for innovations)
- The organizational axis, which comprises the strategy dimension (internal firm strategy, external industry structures) and organizational capabilities (software for innovation, including internal and external capabilities)
- Innovation capability forms the heart of the model in the intersection of market and organizational axes. The core activities and processes which integrate the knowledge and assets on the four dimensions into distinctive bundles of actions are located in the intersection. These activities and processes (innovation business processes, integrative knowledge processes, learning processes) are the source of competitiveness, and keep the firm in the game
- The firm's internal innovation environment comprises its culture, strategy, processes, structures, resources, and activities
- The firm's external innovation environment is the source of economic, technological, political and regulatory uncertainties driven from different forms of competition (IO, Chamberlinian and Schumpeterian)

[9] The use of the framework is illustrated in Edelmann and Koivuniemi (2006) through case studies.

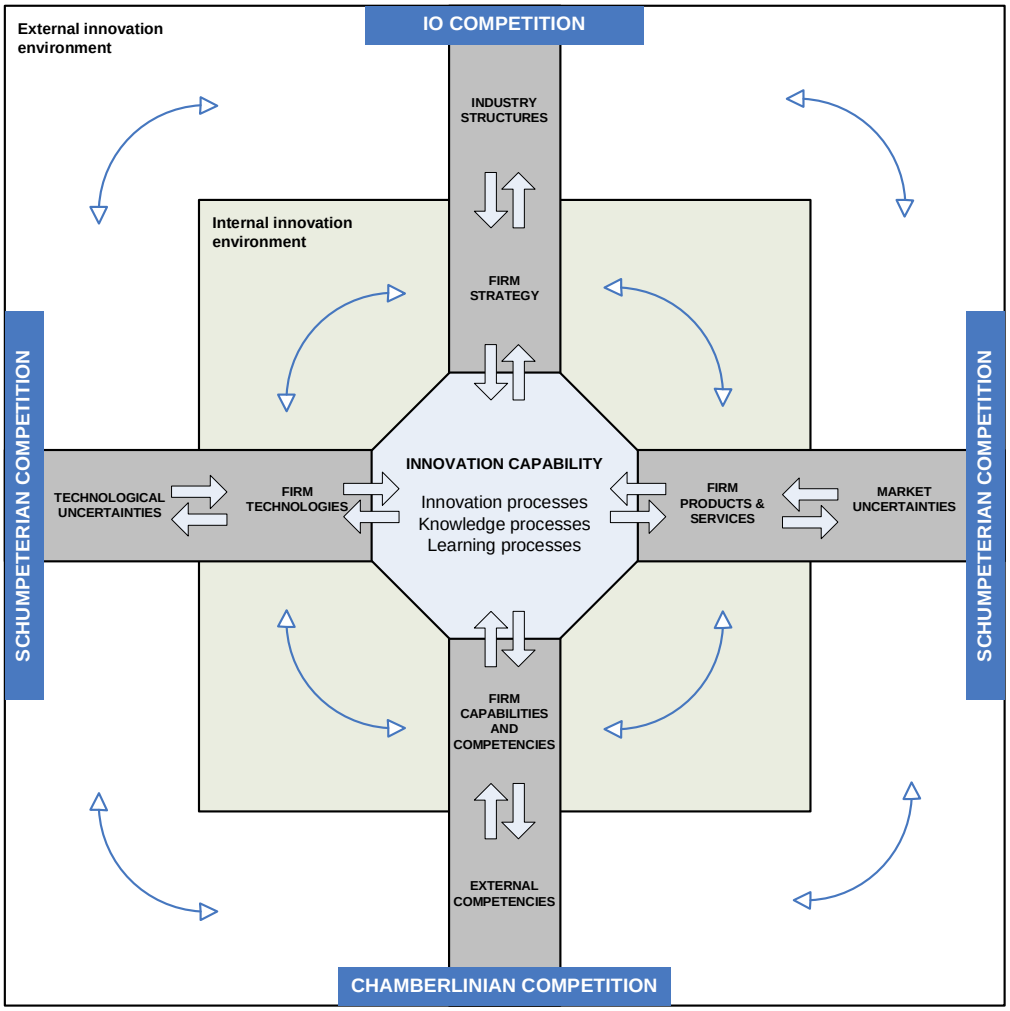


**Figure 8. A framework for networked innovation management.**

The innovation capability is realized through the effective management of the innovation processes, the integrative knowledge processes, and the learning processes. In the strategic context of the front end of innovation, the innovation processes represent the multi-channel model for innovation, and include the operational procedures for managing different types of innovations, e.g. continuous improvement through suggestion system, new products and services idea process, and new ventures idea process. Integrative knowledge processes (e.g. business intelligence activities) are used to combine the knowledge from the outside of the firm to the internal knowledge bases, and refined for use in innovation processes. Learning processes are needed for continuous improvement of the innovation processes and the knowledge processes.

A case description of applying the framework for networked innovation management in analyzing the structural changes of an industry is presented in Appendix 2. The strategic level case description includes an analysis of innovation strategies assessed through the elements of the framework. Later, in Chapter 3.4, the framework is applied for the front end of innovation respectively.

# 3 THE FRONT END OF INNOVATION

## 3.1 Defining the front end of innovation

The front end of innovation constitutes the early phases of the innovation process, before the actual development phase starts. Belliveau et al. (2002, 444) define fuzzy front end (front end of innovation) – "The messy 'getting started' period of product development, when the product concept is still very fuzzy. Preceding the more formal product development process, it generally consists of three tasks: strategic planning, concept generation, and, especially, pre-technical evaluation. These activities are often chaotic, unpredictable, and unstructured". Koen et al. (2002) have provided conceptual clarification on the language of 'the front end'. They suggest that the Front End of Innovation should be used as opposed to the Fuzzy Front End. In their opinion, the fuzzy front end implies that the front end of innovation process incorrectly suggests that it is unknowable and uncontrollable. In recent studies, different terms have been used to describe the front end phase of innovation (see Figure 9).

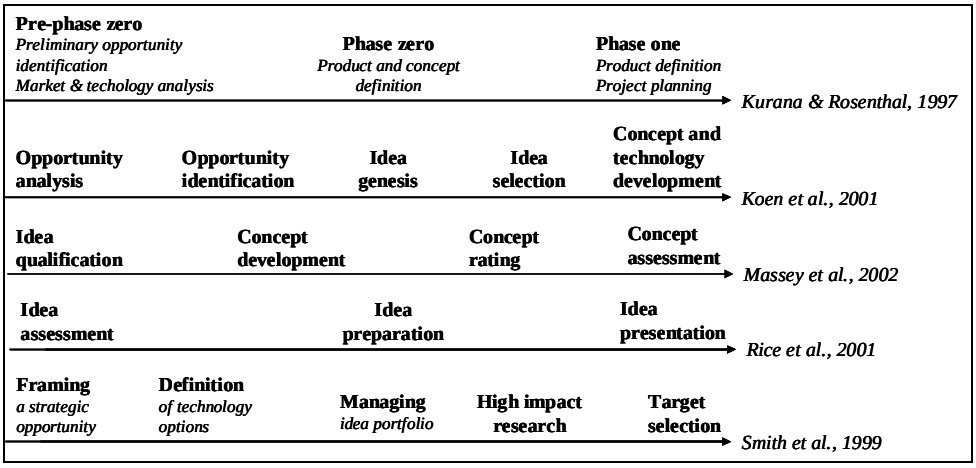


**Figure 9. The phases of the front end of innovation in recent studies (Kola-Nyström and Koivuniemi 2005).**

The front end of innovation can be seen as a multi-channel idea transfer mechanism (Figure 10), which connects internal and external sources of ideas, moves (and proliferates) ideas further through formal and informal processes[10], and disseminates them back to internal and external markets.

The formal processes (formal blueprint) represent the accepted practice of carrying out innovation-related activities in the organization. An innovating organization needs to have these processes in place, to support the innovation management at the whole organization's level, and to support the management of innovation activities towards financial objectives. The formal processes at their best support the creation of effective organization wide routines for innovation.

[10] A process is a series of actions, changes, or functions that bring about a result (e.g. an innovation). In the formal processes the actions are often pre-defined by the organization, whereas the informal processes include actions and functions that emerge during the process.

The informal processes normally exist due to the deficiencies of the formal processes, and they are often at least partly invisible to the management function of the organization. The informal processes are created and practiced by innovating teams and individuals, who consider the formal processes too rigorous or heavy-weight to fully support their ideas and ways of working. The informal processes support flexibility and context-specific adaptation of innovation activities. The innovating organization needs both the formal processes and informal processes, they live side by side. A multi-channel idea transfer mechanism combines intelligently the best features of both.

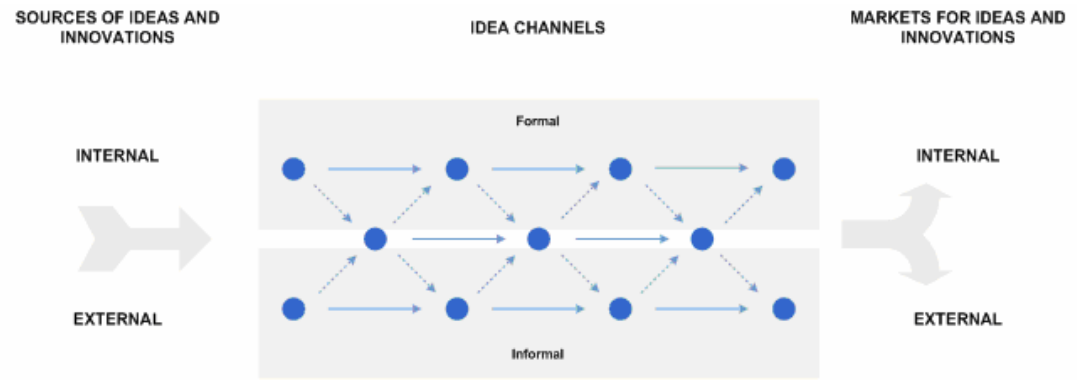


**Figure 10. Sources of ideas, idea channels and idea markets.**

### 3.2 Purposes of the front end of innovation

A broad coverage of purposes can be set for the front end of innovation (the list of potential purposes below is based on Publication 3):

**Resource allocation** – Resource allocation should be one of the fundamental purposes of the front end of innovation. This means allocating time, money and man months during the front end e.g. to opportunity identification and analysis, and to the development of ideas from the embryonic stage to business concepts. The resource requirements for the front end activities are only marginal compared to the total resources needed to bring the products into the markets. However, a commitment to ideas and projects and subsequent resources are made during the front end.

**Decision support** – The foundation for effective resource allocation is that the managers in charge of the front end activities are provided with applicable decision support tools and accurate information on the basis of which the decisions are made. IT systems and project selection methodology play a crucial role in providing decision support.

**Idea development and conceptualization** – Front end models should have strong idea-centered focus to enable the assessment and qualification of the potential and drawbacks of single ideas of different types. Further, the variety of the types of ideas should be understood, as one front end format does not fit all ideas. It can be argued that the existing front end models are often even too much concentrated on the idea-centered approach.

**Portfolio management –** The front end of innovation should provide support for the mapping and management a company's total innovation portfolio. Portfolio management already during the front end of innovation is closely connected to the company's value creation (e.g. the seeds for new businesses are created in the front end among other ideas).

**Opportunity analysis** – A set of activities in the front end should help identify opportunities for new products and businesses. It should be considered whether the opportunities are worth pursuing, and they should be translated into specific business and technology opportunities.

**Information management** – Front end models should allow fluent information flow, as they need input information from various sources internally and externally: customers' needs and values, the competitive situation, the company's goals and strategies, technological opportunities and the company's resources, as well as environmental, social and legislative requirements.

**Systematic guidance** – Front end models should ensure efficient and effective execution of all needed tasks and decisions in a timely and good quality manner – to ensure that the work gets done.

**Teamwork and commitment** – The best innovations and proficient ideas do not occur in a vacuum, nor can they be enriched solely by individuals. Idea generation and enrichment is a social process incorporating groups of people. Appropriate mechanisms should be used to ensure the commitment to the decisions made on different levels. Commitment is a means of amalgamating new ideas to the organization.

**Creativity and innovativeness –** Innovativeness of individuals and organizations is the backbone of the competitiveness and survival of companies. The front end of innovation should provide mechanisms for continuous innovation and the emergence of radical ideas as well. These mechanisms could also serve as engines for innovative development of the front end itself (managerial innovations, process innovations).

**Vocabulary for innovation –** The front end of innovation is often regarded as fuzzy and uncontrollable. For this reason the front end process and its contents and terms should be made understandable and transparent to the innovative organization.

**Customer focus** – Customers are one of the most proficient sources of new product ideas. Customer focus (e.g. lead users) already during the front end would enable direct lock-in to the striving of understanding users' present and future needs (latent and manifested), and quick response to changes (e.g. unexpected uses of technology).

**Internal cooperation** – Cross-functional collaboration is the cornerstone for innovation. Effectively established internal linkages between the "islands of expertise" can leverage the amount of innovative ideas and their quality.

**External cooperation** – The open innovation paradigm expects the innovation systems to become more open to external sources of knowledge and resources in the future, enabling effective import and export of innovations in any phase of the innovation chain. Organizations that can harness this capability will have an innovation-based competitive advantage.

**Risk management** – One of the major tasks of the front end of innovation is to diminish the uncertainties related to the ideas and technological and business opportunities. Effective risk management mechanisms would provide the decision makers with appropriate tools to keep the risks at manageable level while considering new opportunities as strategic options.

**Continuous learning and improvement** – The front end of innovation should be continuously developed and the recognized problems should be overcome. Learning entails also how the organization learns to innovate and improve its innovative capability.

**Measurement** – Applying the measurement perspective already during the front end of innovation would help to address the contribution of early innovation-related activities to the outputs or the outcomes of the whole innovation process. Measuring the innovative capability of the organization would debunk the real sources of innovation-based value creation and the drivers of competitiveness.

**Follow up** – Systematic follow-up would enable tracking of all the decisions made, actions done and results gained. This information can be used to tune the front end of innovation to the needed direction, and it would also enable tracking of ideas back to the very embryonic stage. Tracking would probably disclose new best practices to be applied also in other circumstances, and would enable learning.

**Quality management** – Quality management provides many principles (e.g. TQM) that can be applied as a philosophy to develop the front end of innovation systematically as a process. Quality management would mean capturing internal and external requirements to improve, develop, and maintain quality (e.g. quality of ideas), costs (e.g. more efficient processes), delivery (e.g. flow of ideas through the process), and morale (culture and climate for innovation) continuously.

### 3.3 Contents and critical sub-processes

The front end of innovation process comprises all the activities needed to find, identify and analyse new business opportunities and the intra-firm and inter-firm dialogues through which these ideas[11] are proliferated. In practice the front end activities are often organized around an idea process, which can be defined as a set of interrelated practices used to channel embryonic ideas through elaborating activities to conceptualized development projects, and finally to marketable products, services, and businesses (Kola-Nyström and Koivuniemi 2005). Koen et al. (2002) suggest a new concept development model on the front end of innovation which consists of three parts (see the left part of Figure 11): 1) five key elements comprising the front end of innovation (opportunity identification, opportunity analysis, idea generation and enrichment, idea selection, concept definition), 2) the engine or "bull's eye" which drives the five front-end elements and is fuelled by the leadership and culture of the organization, and 3) the influencing factors which consist of organizational capabilities, business strategy, outside world and the enabling science.

Keeping the open innovation paradigm in mind, we have developed Koen's front end framework further by adding the internal and external knowledge flows in the model (Figure 11). The idea is that a stronger use of cross-border information and knowledge would provide a richer idea base, as well as a larger pool of expertise in the assessment of ideas and concept definition (an example of a working process for joint evaluation of ideas between firms is presented in Chapter 3.4). Next, the critical processes in the front end of innovation are reviewed in detail.

[11] Idea – "The most embryonic form of a new product or service. It often consists of a high-level view of the envisioned solution needed to solve the problem identified by a person, team, or firm." (Belliveau et al. 2002, 445)

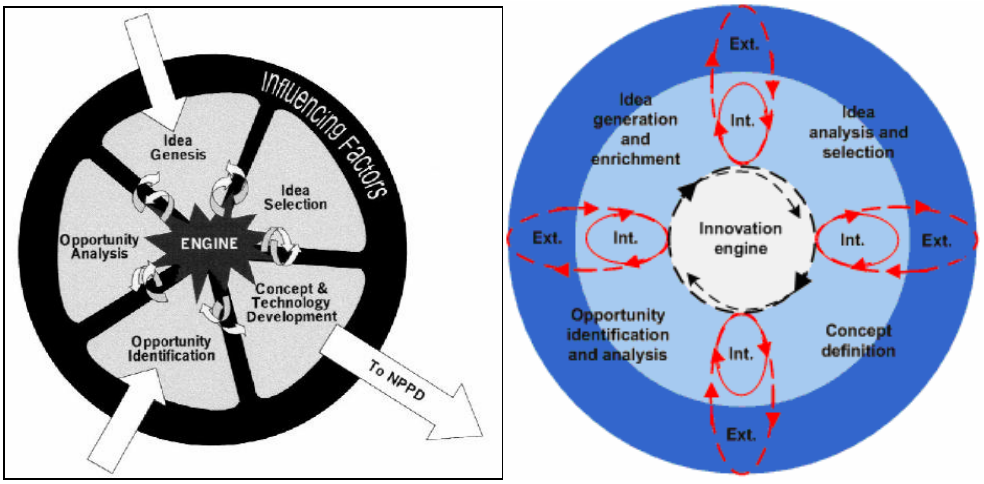


**Figure 11. Cross-border front end of innovation.**

*Opportunity identification and analysis*
In this activity the organization identifies opportunities that it might want to pursue (Koen et al. 2002). Opportunity identification is typically driven by the business goals. The opportunity may be a near-term response to a competitive threat, a breakthrough possibility for capturing competitive advantage, or a means to simplify operations, speed them up, or reduce their cost. Overall opportunity identification defines the market or technology arena the company may want to participate in. Effective methods, tools, and techniques that generate and bundle this information include e.g. roadmapping, customer and technology trend analysis, and scenario planning.

Opportunity analysis constitutes of actions that aim at evaluating the opportunities generated or detected, to decide whether they are worth pursuing. Business capability and competency are assessed in this element, and sponsorship for further work determined.

*Idea generation and enrichment*
Idea generation and enrichment concerns the birth, development, and maturation of a concrete idea. Ideas are built up, torn down, combined, reshaped, modified, and upgraded (Koen et al. 2002). Normally an idea may go through many iterations and changes as it is examined, studied, discussed, and developed in conjunction with other elements of the front end process. The value of the idea generation and enrichment process is defined by the degree to which it is capable of creating large amounts of new ideas, the degree to which it enables a quick examination of the potential and value of the ideas, and the degree to which it provides an easy access to cross-functional and cross-organizational information sources.

Often the best ideas are generated by customers. An example of effective practices of getting valuable ideas is the lead-user method, which aims at involving ‘advanced’ customers in the front end process to capture ideas and get direct feedback from customer propositions and experiences.

*Idea selection*
The main task of idea selection is to decide which ideas to pursue. The problem for most businesses is in selecting which ideas to pursue in order to achieve the most business value. Many approaches to project evaluation and idea selection have been developed. These approaches include several different methods (e.g. Machacha and Bhattacharya 2000, Faulkner 1996, Jackson 1983, Krawiec

1984, Martino 1995, Cooper et al. 1998), and systems/models (Bordley 1998, De Brentani and Dröge 1988, Graves and Ringuest 1991, Iyigün 1993, Jin et al. 1987, Liberatore and Stylianou 1995, Maile and Bialik 1988, Montoya-Weiss, Schmidt and Freeland 1992, Steward 1991, O'Driscoll 2000, Wilkinson 1991). Several studies have compared the developed selection methods and analyzed their benefits and restrictions (e.g. Baker and Albaum 1986, Cooper et al. 1998, Danila 1989, Fahrni and Spätig 1990, Martino 1995, Souder and Mankovic 1986, Twiss 1986). The approaches for idea selection may include formalized decision processes or methods as simple as an individual's choice among many self-generated options. Formalized decision processes are difficult due to the limited information and understanding that are available early in product development (Koen et al. 2002).

According to Higgins and Watts (1986) and the more recent studies by Martino (1995) and Cooper et al. (1998), the use of idea selection methods is quite low in companies, especially the use of complicated, mathematically oriented tools. Simpler methods, such as financial methods, business strategy, bubble diagrams, scoring models, and checklists have been more commonly used (Cooper 1999). The best companies use several complementary methods at the same time (Cooper 1999), which makes it possible to take into account both qualitative and quantitative criteria. However, the criteria for selecting the 'right' idea for highly novel projects are just emerging. Such methods as the options theory and risk assessment are just beginning to emerge with no consensus as to the best method to use (Koen et al. 2002).

*Concept definition*

Concept definition is the final element in the front end of innovation. According to Koen et al. (2002) this element provides the only exit to the new product development or technology development. In order to pass through the gate, the innovator must make a compelling case for investment in the business or technology proposition. The investment case consists of both qualitative and quantitative information. The information may address the objectives, fit to strategies, size of opportunity (e.g. financial impact), market and customer needs and benefits, a business plan (a specific win/win value proposition for value chain participants), commercial land technical risks, environmental and safety 'showstoppers', sponsorship, and a project plan including resources and timing (Koen et al. 2002). The information requirements and criteria vary, depending on the nature and type of concept, as well as the decision makers' attitudes toward risk.

*Portfolio management of ideas*

Portfolio management of ideas can be seen as a separate process, yet inherent part of the front end activities. Hamel (2000) defines the portfolio of ideas as a 'portfolio of possibilities'. Hamel's (2000) innovation model consists of three innovation portfolios: portfolio of ideas, portfolio of experiments, and portfolio of ventures. According to Hamel, few organizations have attempted to collect and manage nonlinear ideas as part of an explicit portfolio of possibilities. Portfolio management is not just the use of portfolio methods in idea selection, but a larger construct which holistically examines a company's portfolio of ideas in different time frames in business. Miller (2001) makes a distinction between managing the stage-gate process of new product development within existing 'dominant designs' and managing the new business development which aims at providing new capabilities and architectures for new dominant designs. Existing dominant designs represent the business today and in the near future, whilst the hunt for new dominant designs represents the business in the future. Then, from the point of view of the front end of innovation, the primary objective for portfolio management of ideas would be to balance and maintain a valuable set of ideas that fulfils the needs of both business horizons. Then, managing the portfolio of ideas can also be seen as a part of idea selection processes: projects on different levels of completion should be periodically reviewed and re-evaluated with the possibility of termination at any time on

the basis of additional information (Twiss 1986). The idea selection process should end up in a set of ideas, which a) is aligned with the company strategies, b) is balanced in terms of defined parameters, and c) yields a maximum value in terms of defined company objectives (Cooper et al. 1998).

### 3.4 Inter-organizational innovation processes and the FEI

Companies establish network relations with other companies to share risks, costs and skills (Ring and Van de Ven 1994). Co-innovative strategies have become crucial for organizations to sustain and strengthen competitive positions in markets (Bossink 2002, Gemünden et al. 1992; Tidd 2005). Bossink (2002) defines four developmental stages for co-innovation strategies:

- Autonomous strategy making: Organizations choose to or are forced to innovate and explore co-innovation possibilities with each other.
- Co-operative strategy making: Organizations negotiate about costs and revenues with each other
- Founding an organization for co-innovation: Organizations enter into contracts, reach agreements, develop innovation plans, found an organization for co-innovation, and establish governance bodies with each other.
- Realization of innovations: Organizations come together to realize innovations, use management methods to manage the process of innovation, and communicate with the market.

Kreiner and Schultz (1993) report three stages of the inter-organizational innovation process:

- Discovering opportunities: Organizations discover collaborative opportunities.
- Exploring opportunities: Organizations explore the opportunities and translate them into concrete inter-organizational innovation projects.
- Consummating collaboration: Organizations develop innovation plans and realize them.

Fisher and Varga (2002) distinguish stages of inter-organizational innovation processes to the pre-competitive stage and the competitive stage. The pre-competitive stage includes information exchange, joint identification of ideas, and jointly conducting R&D. In the competitive stage, prototypes and pilot projects are carried out, and new products are introduced in the markets.

Koivuniemi et al. (2008) present a process[12] (Figure 12) for inter-organizational front end activities applied to the joint evaluation of new business ideas. The process relies on the above co-innovation strategies, and the stages of the inter-organizational innovation processes. The process assumes that the developmental stage of co-innovation strategy is *autonomous strategy making*. Respectively, it is assumed that the firms are *discovering collaborative opportunities*, and they apply the work process at the *pre-competitive stage*.

Referring to the framework of networked innovation management (Figure 8), the process applies the dimensions of the framework as a fundamental source of evaluation criteria for the ideas as follows:

- Market fit: Degree to which there is market potential for the idea? Degree to which the idea is in the scope of current markets and customer base of the company?
- Organizational fit: Degree to which the capabilities needed to implement the idea reside inside the company and degree to which external competencies are needed?

[12] Developed in Talikko project.

- Technological fit: Degree to which the company has the needed technologies to implement the idea in hand?
- Strategic fit: Degree to which the idea is in the scope of the current business strategy and degree to which the idea would require strategic alteration in the firm?

The work process for the inter-organizational front end can include the following activities:

1) Selecting the target group of ideas (e.g. results from a joint idea generation session)
2) Defining idea evaluation criteria for both of the firms by relying on the defined four dimensions (as the evaluation dimensions are generic to the firms, they can define their own sub-criteria and weights for the criteria)
3) Defining evaluation responsibilities for the ideas in the both firms (potentially using external experts)
4) Carrying out the evaluation of ideas in both firms
5) Combining the evaluation results
6) Firm specific workshops to analyze results
7) Joint workshop for knowledge exchange among idea groups c and d (see Figure 12)
8) Agreeing further actions concerning idea groups c and d (i.e. taking possible further steps in the stages of co-innovation strategies)

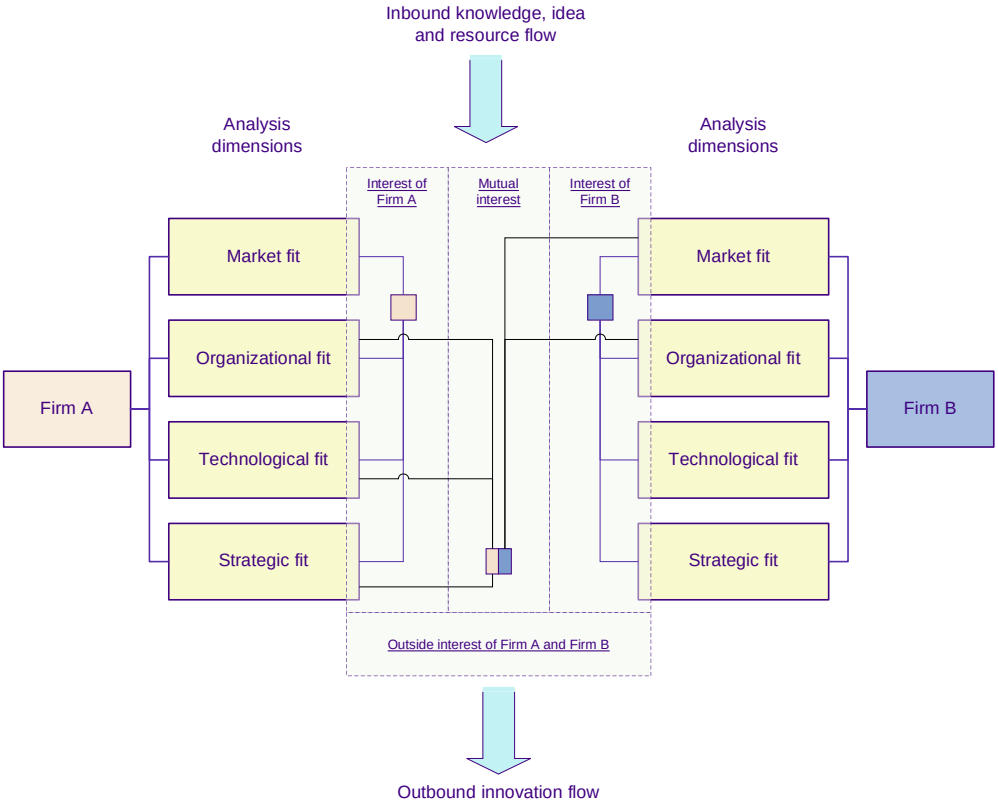


Figure 12. Inter-organizational front end framework.

The application of the evaluation strategy creates four pools of ideas (Figure 12). Ideas in the interest of firm A or firm B represents the subset of ideas in which no cooperation between the companies is anticipated due to missing complementarities of interests. The ideas might be further developed and realized by the company itself, or together with other partners not participated in the joint session. Mutual interest group of ideas is a subset of ideas from company specific idea pools. This group represents ideas where mutual interest between the firms has been recognized. For instance, firm A finds an idea strategically viable, and it also has organizational and technological capabilities for implementation. Respectively, firm B might have complementary organizational capabilities and a clear vision about the market potential. Even if the idea falls outside the current strategic scope of firm B, it might reclaim the option to scout future emerging strategies. Ideas outside the interest of firm A and firm B represents ideas in which neither company have interest in (non-core ideas). However, this group of ideas could be probably handed over to the markets bearing in mind that some other companies might find them useful. Here, open innovation strategies can be applied.

# 4 INNOVATION AND IDEA MANAGEMENT SYSTEMS

The aim of this part of the thesis is to provide an overview of the supportive systems of innovation processes, particularly in the scope of the front end of innovation. While the coverage of available systems and methods is abundant, the organizational knowledge management approach has been selected as the framework for presenting the typology of innovation and idea management systems.

## 4.1 Systemic support for innovation management

Innovation is increasingly seen as a process, not a single act (Cooper 1999, Koen et al. 2002, Tidd et al. 2005). Even though management of innovation is the most knowledge-intensive organizational process, its information technology support has received only fragmented attention (Adamides and Karacapilidis 2006). The role of information technology is to structure the innovation process in a manner that it on one hand encourages divergence of perspectives, and on the other, convergence to valuable outcomes is attained.

Dooley and O´Sullivan (2003) propose design goals for the development of a Systems Innovation Management (SIM) framework and supportive software:

- The software should be goal-centred
- The software should be action-based
- Correlating between the SIM approach and supporting software
- The software should encourage a team focus
- The software should adopt a process perspective
- The software should be results-orientated, and
- The software platform should support groupware communication.

In the list of these design goals, several issues are worth focusing on. Innovation management systems should always be designed for a particular purpose. The action and groupware-based system also supports the participation of organizational members. The team focus supports cooperation and mutual learning. The process perspective is essential in supporting bundles of actions, not separate tasks. This feature enables innovation management systems to become more coordinated in relation to organizational goals. The results-orientation supports purposeful innovation management. While the role of systems is normally supportive by nature, they can also be used as performance support systems (Montoya-Weiss and O'Driscoll 2000).

## 4.2 Knowledge management and innovation management systems

Because innovation is a complex knowledge-intensive process, innovation management systems can be presented from the knowledge management perspective. Tuomi (1999) presents a holistic structure of knowledge management disciplines (Figure 13), which links systems in many instances to innovation management systems.

Innovation management systems need to support organizational information processing (information processing, information sharing, organizational communication). The discipline of organizational development is relevant in designing an organization's innovation processes. Organizational intelligence, and particularly business intelligence, is needed in providing innovation processes with a rich knowledge base from the markets, technologies, etc. (Pyötsiä 2000).

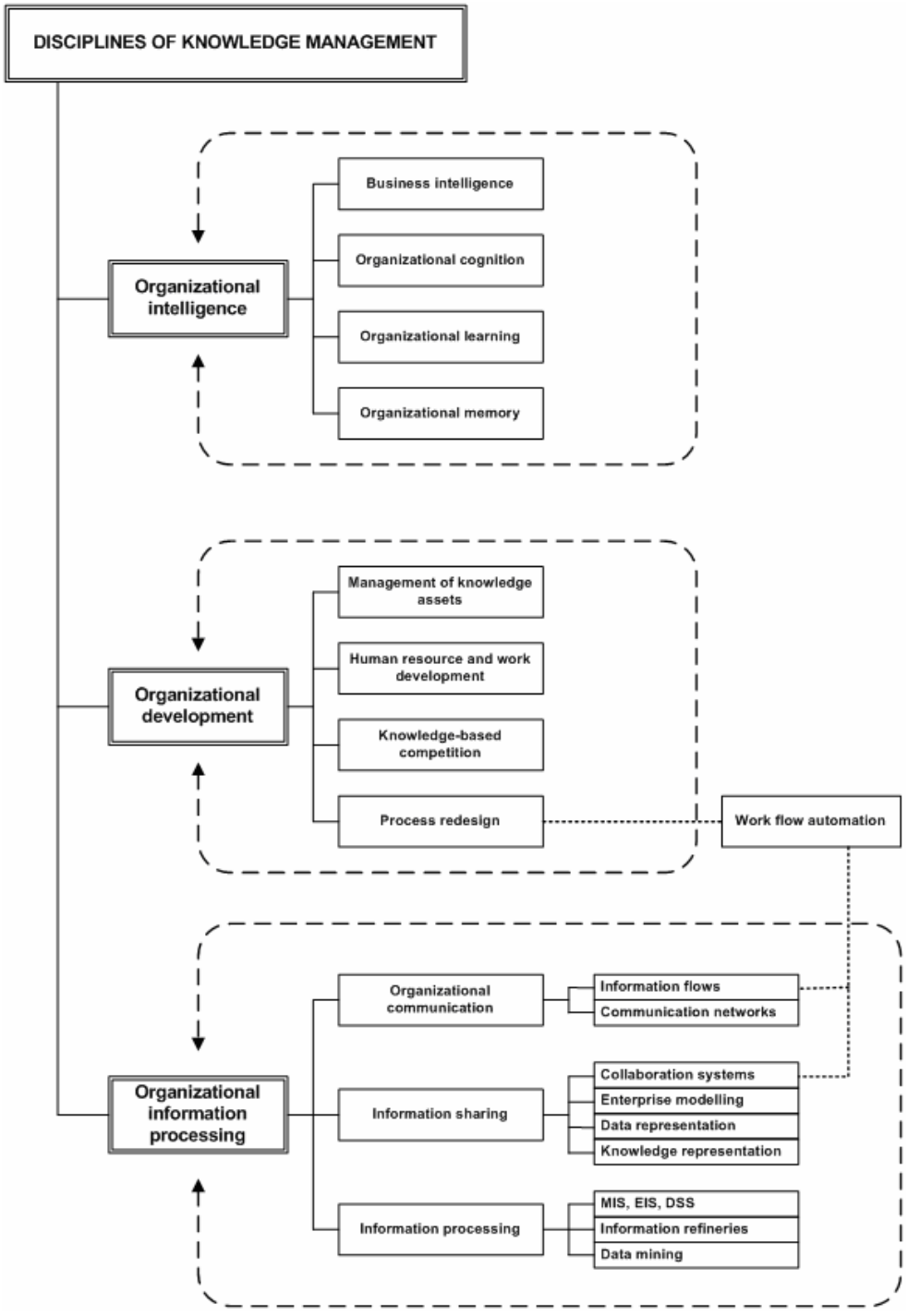


**Figure 13. Disciplines of knowledge management (Tuomi 1999).**

Information technology can be used to help increase innovation productivity in organizations (Gordon et al. 2008). Information systems can be used in collaboration, knowledge sharing, competitive intelligence and in many other ways (see Table 3) to help people generate ideas and develop them into good currency.

**Table 3. Use of information technology in the front end of innovation (adapted from Gordon et al. 2008).**

| How can it help? | Corresponding FEI activities |
|---|---|
| **Collaboration –** IT can help internal teams of innovators collaborate with one another and with innovation networks (partners, suppliers, customers) to exchange ideas and solutions. | Idea generation and enrichment;<br>Idea analysis;<br>Concept definition |
| **Competitive intelligence –** IT can be used by innovation teams to gather competitive intelligence. | Opportunity identification and analysis |
| **Accessing and organizing information –** IT can be used by innovators to organize and access information and organizational knowledge (make sense of data). | Opportunity identification and analysis;<br>Idea analysis and selection |
| **Simulation and optimization –** IT can be used for mining and analyzing data and for simulation, optimization and model building (for prototyping and early exploration of ideas) | Idea analysis and selection;<br>Concept definition |
| **Visualization –** IT can be used to manipulate and observe the impacts of changes in design parameters in experiments. | Concept definition |
| **Ideating –** IT can be used to brainstorm and think outside the box. | Idea generation and enrichment |

### 4.3 Idea management systems

Idea management systems can be defined as any combination of methodology and tools (manual or IT-supported) that enhance the management of innovations within their early phases. Based on this definition, idea management systems can be divided into the following groups in accordance with the main activities of the front end of innovation:

- **Idea generation systems and techniques**, which can be divided by their effect on the paradigm (e.g. Garfield et al. 2001, McFadzean 2001), paradigm-preserving and paradigm-modifying. Another distinction is to divide idea generation techniques into convergent and divergent techniques. Group support systems and groupware are most often used in the generation of ideas.
- **Idea analysis and selection systems** are often under the label of R&D project selection systems, which have a long history of techniques and systems from simple check list models to expert systems (Bordley 1998, De Brentani and Dröge 1988, Graves and Ringuest 1991, Iyigün 1993, Jin et al. 1987, Liberatore and Stylianou 1995, Maile and Bialik 1988, Montoya-Weiss, Schmidt and Freeland 1992, Steward 1991, O'Driscoll 2000, Wilkinson 1991).
- **Portfolio management systems and approaches**, which aim at examining groups of ideas at a time for prioritization and managing the total portfolio of ideas. The role of these systems is important also in finding linkages between single ideas.

In broader systems the various activities in the front end are often combined under an integrated system to provide seamless information management over activities and tasks (e.g. Montoya-Weiss and O'Driscoll 2000). The other extreme is the use of various separate methods and tools, which on one hand provides flexibility, but on the other hand makes it difficult to manage the whole process of innovation.

In the classification of innovation management systems (Figure 13), most of the "traditional" idea management systems belong to the group of decision support systems under organizational information processing.

# 5 RESEARCH STRATEGY AND METHODOLOGY

This chapter presents an introduction into the relevant research methodological approaches in the scope of the thesis.

## 5.1 Categorization of relevant qualitative research approaches

Neilimo and Näsi (1980) categorize four research approaches (Figure 14). In the nomothetical approach (sometimes called positivistic approach), the underlying explanatory model is causal, and attempts are made to state the findings in the form of general laws. Deduction, hypotheses, models and empirical testing play a key role. This approach applies mostly in natural sciences, and is a common approach in economic research. The decision-methodological approach aims at constructing models for decision making and problem solving. It is normative by nature, and theoretical analysis and thinking are important. The action-analytical approach brings the human being into the focus of analysis, and often the researcher is one of the subjects affecting the phenomena. For this reason it is also known as subjectivistic research approach. The goal of the conceptual approach is to construct new concept systems when the background is previous conceptual or empirical research. Table 4 summarizes the features of these research approaches. The constructive research approach is found in the intersection of normative and empirical approaches, and explained further in the next chapter.

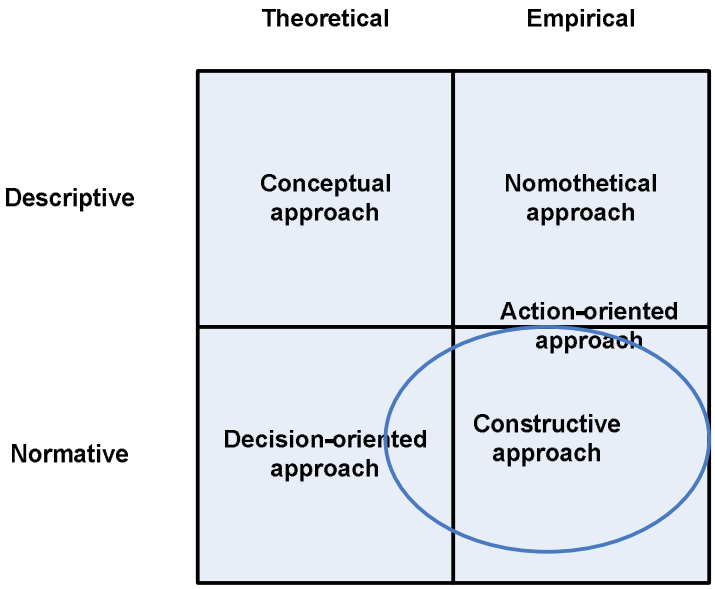


**Figure 14. Constructive research approach in relation to other resarch approaches (Neilimo and Näsi 1980, Kasanen et al. 1991)**

**Table 4. Research approaches in industrial economics (Neilimo and Näsi 1980, Kekäle 2001).**

| Concept-analytical approach | Nomothetical approach | Decision-oriented approach | Action-analytical approach |
|---|---|---|---|
| Goal: to construct new concept systems | Goal: to explain causal relations | Goal: to design problem-solving methods | Goal: to understand (or to change) |
| Background: earlier conceptual or empirical research | Background: positivism | Background: micro-theory, game theory, decision theory and positivism | Background: teleological explanation |
| Method thinking, new concepts by analysis and synthesis | Scientific ideal: behavioral sciences used in a natural-scientific way | Scientific ideal: mathematics and logic | Scientific ideal: Aristotelian action science, human science |
| Providing mainly by means of argumentation | Empirical part plays an important role of application. | Empirical part usually an example | Empirical proving usually by selected cases |
| Research subjects can be facts, values or norms. | Rich methodological rules system | Research process follows loosely axiomatic principles | No established methodological rule system |
| Results can be both descriptions or 'languages' | Results in form of regularities or recommendations | Results in form of solutions or explicated 'natural laws' | Results often concept systems or problems of different levels |

## 5.2 Constructive research approach

The main objective of the constructive research approach is to build new constructs or models, which are on one hand related to earlier theoretical knowledge, and on the other hand try to solve managerial problems. Because the constructive research approach is a strongly problem-based research approach, theory development through the approach is difficult without a broader application and testing of a solution construction. The contribution of the solution construct is measured by its practical functioning and value, and an attempt needs to be made to assess the theoretical utility of the solution construct (Figure 15).


**Figure 15. Constructive research approach (Kasanen et al. 1993).**

The workflow of the constructive research approach consists of six phases (Kasanen and Lukka 1993):

- § Finding a practically relevant problem which has research potential as well
- § Examining the potential for long-term research cooperation with the target organization(s) (Lukka 2000)
- § Obtaining a general and comprehensive understanding of the topic
- § Innovating, i.e. constructing a solution idea
- § Demonstrating that the solution works
- § Showing the theoretical connections and the research contribution of the solution concept
- § Examining the scope of applicability of the solution

### 5.3 Case study research

According to Eisenhardt (1989), case study is a research strategy which focuses on understanding the dynamics present within single settings and can employ an embedded design, that is, multiple levels of analysis within a single study. Case studies typically combine such data collection methods as archives, interviews, questionnaires and observations. Another definition is provided by Yin (1994) "A case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between the phenomenon and context are not clearly evident; and in which multiple sources of evidence are used." Case study has been considered as a weak method among social sciences because of the following reasons: the researcher may have biased views that influence the direction of the findings and conclusions, they provide little basis for scientific generalization, and massive and unreadable documents are involved. However, Eisenhardt (1989) has proposed a process (Table 5) for building theories from case study research. Theory building from case studies is a careful process with several iterative rounds of analysis and multiple data collection methods, which should be used to provide multiple sources of evidence for the findings.

Case studies often require laborious data collection in written format, and interpretation of data from multiple sources. In the qualitative case study research, the analysis and reporting of the results should be given high emphasis, as well as the way of writing and presenting the findings clearly (de weerd-Nederhof 2001).

Bonoma (1985) defines a four stage process model for case research. The first stage is called the drift mode. This stage consists of the investigator's attempts to learn the concepts, locale, and jargon of the phenomenon as it occurs 'in the field', and to begin preliminary integration from literature, a priori notions about the phenomenon's operation, and critical components of practice as observed. Most research methods involve this sort of a situation analysis stage. The second stage called the design includes the development of a tentative explanation of the divergent observations so far collected. The object of data collection is to assess and refine major areas of inquiry suggested by the preliminary model. The third stage of case research is called the prediction or generalization-formation stage. The research will compile more cases from sites that are different from, but conceptually similar to, those sites used to arrive at the generalizations. This step usually requires evaluating the generalization in industries or settings not yet explored. The fourth stage, disconfirmation, consists of further testing the limits of generalizations not rejected in the prediction stage. An attempt is made to disconfirm the tentative generalizations by applying them to another set of cases than was sought in the prediction stage. The contexts for these cases should be

**Table 5. Process of building theories from case study research (Eisenhardt 1989).**

| *Step* | *Activity* | *Reason* |
|---|---|---|
| *Getting started* | Definition of research question<br>Possibly a priori constructs<br><br>Neither theory nor hypotheses | Focuses efforts<br>Provides better grounding of construct measures<br>Retains theoretical flexibility |
| *Selecting cases* | Specified population<br>Theoretical, not random, sampling | Constrains extraneous variation and sharpens external validity<br>Focuses efforts on theoretically useful cases, i.e. those that replicate or extend theory by filling conceptual categories |
| *Crafting instruments and protocols* | Multiple data collection methods<br>Qualitative and quantitative data combined<br>Multiple investigators | Strengthens grounding of theory by triangulation of evidence<br>Synergistic view of evidence<br>Fosters divergent perspectives and strengthens grounding |
| *Entering the field* | Overlapping data collection and analysis, including field notes<br>Flexible and opportunistic data collection methods | Speeds analysis and reveals helpful adjustments to data collection<br>Allows investigators to take advantage of emergent themes and unique case features |
| *Analyzing data* | Within-case analysis<br>Cross-case pattern search using divergent techniques | Gains familiarity with data and preliminary theory generation<br>Forces investigators to look beyond initial impressions and see evidence through multiple lenses |
| *Shaping hypotheses* | Iterative tabulation of evidence for each construct<br>Replication, not sampling, logic across cases<br>Searching evidence for "why" behind relationships | Sharpens construct definition, validity, and measurability<br>Confirms, extends, and sharpens theory<br><br>Builds internal validity |
| *Enfolding literature* | Comparison with conflicting literature<br>Comparison with similar literature | Builds internal validity, raises theoretical level, and sharpens construct definitions<br>Sharpens generalizability, improves construct definition, and raises the theoretical level |
| *Reaching closure* | Theoretical saturation when possible | Ends the process when the marginal improvement becomes small |

characterized by extreme conditions where the generalizations' limits might be expected to be exceeded. The four stages do not form a rigid hierarchy, but rather an iterative evolution toward understanding.

### 5.4 Criteria for judging qualitative research

According to Denzin and Lincoln (2000) and Robson (1993), the following criteria can be used in the evaluation of the validity of research (adapted from Elfvengren 2006):

**Credibility** – The objective is to demonstrate and ensure that the subject of enquiry is accurately identified and described. The researcher verifies that his opinions correspond with the opinions and perceptions of the subjects of the studied area.

**Transferability** – The potential transferability of the research findings to other environments. The purpose is to provide a description which helps the reader to understand the research findings; this helps to evaluate whether the case can be transferred to other environments. May mean that the study is used in further research in other settings.

**Dependability** – Analogous to reliability. Assessment of the research process; whether it is clear, systematic, and well documented. The researcher's biases should also be evaluated.

**Confirmability** – Judging the sufficiency of the research process. Evaluation of whether the research findings flow from the data.

# 6 SUMMARY OF PUBLICATIONS

This section of Part I presents summaries of the publications in Part II, including their objective(s), main contents, and main contribution. The summary data of all the publications is presented in Table 6. The publications are presented in a non-chronological order to provide a logical structure for the dissertation. A content and results based interdependency structure between the publications is presented in Figure 16. The presentation order of the publications follows mostly the logical dependency structure presented in Figure 4. Accordingly, strategy-focused publications are presented first, followed by process-focused publications, and then the systems-focused papers. Publication 7 is an exception, as it presents a lot of new ideas on the strategy and process perspectives.

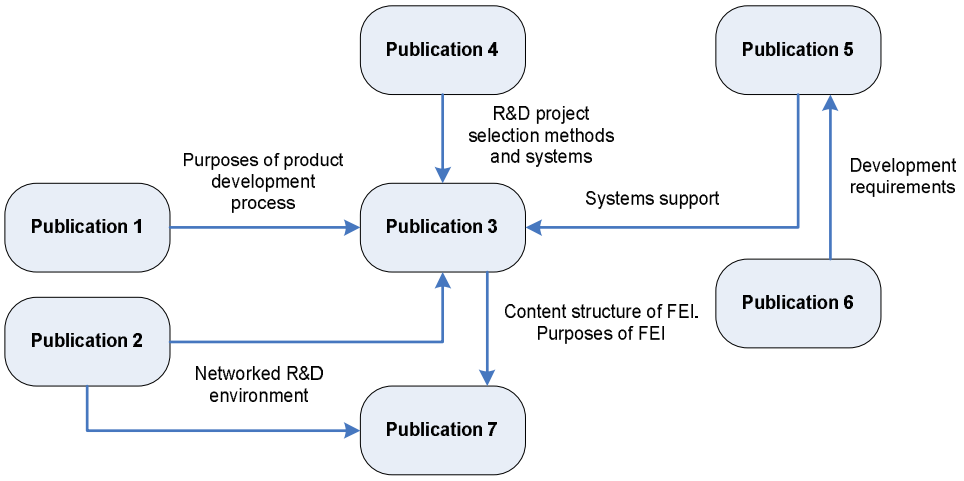


**Figure 16. Content and results-based interdependencies between the publications.**

## 6.1 Publication 1: Purpose of the product development process

*Objective*

Publication 1 presents different purposes for product development processes (PDP) on the basis of literature, and analyses them further. The purposes are analysed in the light of selected management concepts: process management, knowledge management, systems thinking, portfolio management etc. The aspects of cross-functionality and globalisation in product development are also taken into account. The analysed purposes are examined in relation to five companies' present PDPs to examine the degree to which the purposes are included in the product development and its process models in the firms.

*Main contribution*

Publication 1 results in a broad set of different purposes for a PDP, derived from a literature survey and interviews. The purposes include but are not limited to the following: a) to help carry out the right things in the right time with the right resources, b) to promote controllability, systematics and risk management in product development, c) to ensure the availability of quality input information for product development, d) to coordinate the tasks of different functions and departments, e) to

promote learning and continuous improvement in product development, and f) to help take the entirety into account in single decisions. Most of the defined purposes support each other, and some of them are partly overlapping. Systematic guidance, promotion of customer focus and support for co-operation and risk management is one of the most common and fundamental purposes. Promotion of creativity is a partly contradictory purpose, because the product process should support systematic, fast, and straightforward implementation of projects, but creativity is also needed in problem solving and creation of differentiated solutions.

All the management concepts are strongly related to the defined purposes of the PDP. The concept of risk management is most strongly related to the purposes of the PDP. This outcome is natural, because a considerable number of risks are related to all the decisions and tasks of product development. The weakest links exist between the management concepts and the purposes of promotion of creativity, and dividing the process into differently manageable, but also well integrated R&D&E areas. Most of the purposes were included in all the studied companies' PDP models and instructions. Systematic guidance and support for co-operation, communication and business process integration were the most emphasised purposes in the studied companies' PDPs. However, explicit determination of the needed inputs in the starting phase were missing in some PDPs. Promotion of creativity, support for continuous learning and improvements, as well as help to remove practical problems were the least emphasised purposes. The studied companies saw a lot of potential to promote continuous learning and improvement, partly due to a lack of mechanisms and sub-processes for them. The importance of the least emphasised purposes might increase in the future. The principles and guidelines of knowledge management and risk management could help in this work. Other concepts than the analysed and perhaps totally new management concepts might be needed to promote creativity.

The results are applicable for companies and provide also interesting research directions in the academic context. The different purposes of the PDP and their examination in relation to the management concepts help companies to rethink the role and contents of their PDPs. As there are still many companies not having a formal process for managing product development, the first step to start would be to define the purpose for which the PDP is designed and realised. A predefined list of different purposes helps to focus the essential purposes and adopt them. When more purposes are to be applied, the list of purposes presented in this paper can be used to study which purposes support each other and which purposes are conflicting. The management concepts and their principles have been used largely in companies. Companies can study if they have applied the management concepts in product development environment and in the PDP. This paper clarifies which management concepts could be used to reach one or more purposes of the PDP. The companies already having a PDP could extend its coverage by defining new purposes and means to reach these purposes.

*Role of Publication 1 in the thesis*

Publication 1 represents the strategy and process perspective of the thesis. It provides a rich view of the possible content configurations of product development processes. For the thesis it represents a purposeful and strategic approach for product development and innovation processes. It also provides an analysis of topical management concepts put into practice in the product development processes of the analyzed firms. The extensive list of purposes for PDPs presented in Publication 1 is applied in Publication 3 to derive purposes for the front end phase of the innovation process.

**Table 6. Summary of the objectives, data, methods and contribution of the publications.**

| | *Publication 1* | *Publication 2* | *Publication 3* | *Publication 4* | *Publication 5* | *Publication 6* | *Publication 7* |
|---|---|---|---|---|---|---|---|
| *Title* | The Purpose of Product Development Process | Towards Networked R&D Management: Sonera Corporation's R&D management in the Dynamic Environment as an Example | Anatomy of the Front End of Innovation: Contents, Shortcomings and Trends | R&D Project Selection Methods and Systems in Innovation Management: A Process Based Approach | Intranet Based System for Product Innovation Management Process | A Groupware Tool for R&D Project Selection in Distributed Company Environment | Towards Internally and Externally Open Front End of Innovation: A Case Study from the Pulp and Paper Industry |
| *Perspectives covered*[13] | Strategy; Process | Strategy | Strategy; Process; Systems | Systems; Process | Process; Systems | Process; Systems | Strategy; Process |
| *Objective(s)* | To analyze different purposes for product development processes. To examine the degree to which the purposes are included in the present product development processes of five companies. | To define a networked R&D management approach that emphasizes internal and external collaboration networks as critical for companies operating in a dynamic business environment. | To provide a holistic analysis of the contents and structure of the FEI, including the potential of inter-organizational collaboration, knowledge sources and emerging IT tools and systems. | To provide a process-based analysis of R&D project selection methods and systems and their data requirements. | To build a system framework to promote product innovation management and support the use of management processes by using the possibilities of internet technologies. | To develop a management process and groupware tool for R&D project selection, covering the activities from idea gathering to the analysis of ideas in a portfolio. | To construct a framework for internally and externally open front end of innovation, which takes into account internal and external mechanisms of idea exchange, as well as the industry trends and drivers. |
| *Data / methods* | Literature review; Interviews; Case study (5 firms); Firm specific data on product development processes | Literature review; Participation action research; Illustrative case study (one firm); Interviews | Literature review; Conceptual approach; Constructive approach | Literature review; Conceptual approach | Literature review; Constructive approach; System design | Literature review; Constructive approach; System design | Literature review; Interviews; Case study (three idea processes within one firm); Firm-specific data on idea processes |
| *Main contribution* | Extensive list of common, important purposes of product development processes. Insights on the realization of the purposes in practice in the studied firms. | Merging the theories of innovation into a networked R&D management approach to provide a foundation for modern R&D management. | A holistic framework for the front end of innovation within the internal and external business domains of a firm. | Understanding the use of R&D project selection methods (their potential and limitations) as embedded parts of the activities and tasks of innovation processes. | A framework and its internet-based application to promote product innovation management and the use of management process models. | A process model and groupware tool for R&D project selection for a distributed company environment. | Insights into a practical application of the open innovation paradigm in the front end of innovation, and theoretical advancement of the open innovation framework. |

[13] This issue refers to the research perspectives defined for the study, which were described in Chapter 1.2. The research perspectives include strategy, processes and systems of innovation.

## 6.2 Publication 2: Towards networked R&D management

*Objective*

Publication 2 delineates the challenges of a dynamic environment to R&D management, and builds on the most recent ideas, such as the dynamic capability view of the firm, as a strategic foundation for modern R&D management. Collaboration is emphasized as a meta-capability for innovation. These ideas are merged into a 'Networked R&D Management' approach that emphasizes internal and external collaboration networks as critical for companies operating in a dynamic business environment. The approach is illustrated with ICT industry as an example. The implementation of Networked R&D Management is reflected in an illustrative case discussion of the R&D management of Sonera Corporation.

*Main contribution*

Publication 2 reviews the state-of-the-art of the R&D management theory (based on the fourth and fifth generation innovation management), dynamic capability view of the firm, and collaboration as a meta-capability for innovation. The fusion of these theoretical concepts and ideas forms an approach named 'Networked R&D Management'. The approach emphasizes internal and external collaboration networks as critical for companies facing a dynamic business environment. The research approach can be described as participation action research (Ottosson 2003), where the researchers act not only as researchers but also actively participate in the business. The combination of the inside and outside views enables a deeper understanding of the complexity in R&D management. The participation action research approach reveals also soft issues and enables holistic understanding. Two of the authors of this paper have worked for the case company's R&D management for several years. All the authors have clinical experience from other companies, and also a solid academic background in the areas of knowledge management, strategy and innovation management, as well as information and communications technology.

The networked R&D management approach has been constructed by assessing the environmental drivers derived from the dimensions of R&D management, which include: the scope of R&D, the locus of R&D, organizing for networked R&D, integrated R&D strategy, the role and nature of innovation, knowledge & competencies & IPR, customers & partners & suppliers, financing, and the role of information technology. Several issues can be pinpointed in the Networked R&D Management approach as a response to environmental drivers and changes in these dimensions. A holistic and multi-disciplinary approach is needed. The scope of the Networked R&D Management is broader than in traditional R&D management, and also non-technological issues, such as new business models are emphasized. In order to increase flexibility and fast responsiveness, close integration with business strategy, as well as strong customer and market orientation have become crucial. Networked R&D Management emphasizes both internal and external collaboration. Internal coordination and collaboration are still major challenges, and cross-functional in-company collaboration must be enhanced e.g. by setting up cross-functional teams. External R&D networks include collaboration and integration with complementary corporations, suppliers and customers, as well as universities and research centres. The non-core competencies are outsourced and leveraged from markets or collaborative partners. In the changing environment, companies should focus on their dynamic capabilities beyond specific technologies. Incremental and radical innovations have to be managed simultaneously, as do also the different time horizons and roles in the Networked R&D Management model. Co-learning within clusters of key customers, collaborating companies, suppliers and universities may enable both incremental and radical innovations. Especially in the

emerging and dynamic markets, shared knowledge creation and innovation may speed up market development. Absorptive capacity and capability to manage independent actors in multiple networks become increasingly critical. Collaboration becomes a critical meta-capability enabling the development of all other capabilities. Fundamentally, the capability to collaborate in internal and external networks becomes a source for competitive advantage.

*Role of Publication 2 in the thesis*

Publication 2 represents the strategy perspective of the thesis. It presents a list of environmental drivers, which fundamentally trigger the initiation of the networked R&D management model. Publication 2 provides a modern framework for networked R&D and innovation management in a dynamic company environment. It delineates pivotal issues and directions of R&D management towards more networked approaches, where competitiveness depends on the actors' capability to combine with complementary partners. The framework provides strategic foundation for advancing firm-specific R&D and innovation management practices. Publication 2 provides an insightful networked micro-context of innovation for use in relation to the other publications in the thesis.

### 6.3 Publication 3: Anatomy of the front end of innovation

*Objective*

The purpose of the paper is to provide a critical analysis of the goals and contents of the front end of innovation. The paper aims at constructing a relational model to examine the linkages between the aims of innovation, the front end of innovation as a business process, and other internal and external business domains. New emerging trends, the open innovation paradigm, cross-organizational arrangements in the early phases of innovation, and the potential of integrated IT based systems as the next phase in the evolution of front end models are discussed. The key issue is that a modern networked organization needs to understand the front end of innovation as an organic part of its business system. Organizations get connected to the origin of their business value creation as soon as they integrate the front end of innovation explicitly to other business processes.

*Main contribution*

The analysis includes a relational model of the critical building blocks for the front end of innovation, which can be derived from its fundamental purposes. The purposes of FEI in Publication 3 have been derived from the purposes of product development processes presented in Publication 1. Some of the most critical building blocks of the front end can be summarized as follows: emphasis on single ideas in order to open up their potential, establishing alternate idea tracks, amalgamating ideas to the organization through various mechanisms, managing the portfolio of ideas, managing the linkages to critical knowledge and information sources, and managing the linkages to internal and partly external business processes.

Understanding the various purposes of the front end is the cornerstone of planning future front end models with richer adaptable contents and structure. In the future, the front end models are expected to include more external linkages, as expressed by the open innovation paradigm. Some examples are already visible in practice, for instance the emergence of idea markets that are fuelled by open-minded organizations willing to share and benefit from external knowledge both by exporting ideas that are not in the area of their core business and actively importing ideas from external sources. A new genre of organizations is probably emerging in the form of idea brokers, who act as idea

intermediaries and chokes between innovative organizations. Inside particular organizations this phenomenon has already been present in the form of knowledge brokers.

The media through which the front end models are presented define largely the format and contents that can be shown. IT tools can be used to illustrate the format of the front end, and to implement and represent most of the purposes of the front end of innovation. The format is often just the tip of the iceberg, and the contents can be found by drilling down through the elements included in the front end format. In addition to using IT to present the front end as a blueprint, IT is inevitably a necessity in today's effective front end models. From a company's perspective, the establishment of IT systems to support the front end is an IT investment among other investments. As the electronification of the whole innovation system is under way, the importance of IT systems in the front end context becomes more crucial. The tendency is also clearly towards integrated information systems that can cover whole processes (bundles of activities) from the very begin to the end, and integrate business processes together also between organizations. This should make the separate commercial tools for e.g. R&D project selection less attractive, and meanwhile a comprehensive planning approach on the organizational information systems should leverage the potential of the front end of innovation.

A common language for the front end of innovation, e.g. a vocabulary for innovation, should be provided to ensure the transparency of the front end. These kinds of supportive elements are important also in promoting the direction, innovativeness and flexibility of the front end processes. The direction and innovativeness supported by the leadership and culture of an organization would keep the front end of innovation running. Flexibility is needed, because the front end of innovation is iterative by nature, the operating environment is constantly changing, and the value drivers for different stakeholders vary. A right set of effective tools, methodologies and methods, as well as capabilities in using them would keep a company well prepared for changing situations. The front end of innovation is a socio-technical decision making and management process. It incorporates people (individuals and groups), processes, systems, technology, methodologies, methods, data, and information. The use of different methods and systems can hardly be promoted without understanding the whole system and its linkages to other business processes.

*Role of Publication 3 in the thesis*

Publication 3 represents the strategy, process and systems perspectives of the thesis. The developed thematic structure for the front end of innovation puts together essential issues in these perspectives, and helps create a deeper understanding of the critical contents of firm level FEI processes. This view is augmented with the purposeful development of FEI models with the help of defined purposes of FEI. The FEI model also builds upon the ideas of networked R&D management (Publication 2) by defining a bi-directional knowledge channel to external organizations. The issues presented in Publication 3 have generated the basis for Publication 7, which presents a case study in the front end of innovation.

### 6.4 Publication 4: R&D project selection methods and systems in innovation management

*Objective*

The purpose of the paper is to provide a process-based analysis of R&D project selection methods and systems. The paper investigates critically the usability of different methods and systems to support the whole R&D project selection process, consisting of idea gathering, screening, evaluation, and prioritization of ideas and projects. The analysis does not concentrate solely on the

methods, but more specifically on their applicability and integration in relation to critical activities in the R&D project selection process. The paper also explores the existing information technology-based systems supporting the R&D project selection process and the applicability of these systems in promoting the use of effective methods. The process-based approach is used to reflect adequately the realities faced by R&D managers in companies.

*Main contribution*

In practise the catalyst for establishing R&D project selection systems and methods has been driven by practical needs in organizations. However, it can be argued that organizations suffering from shortcomings in R&D project selection have probably not concentrated adequately on the establishment of an organization-wide understanding about the problems, development requirements and needs concerning R&D project selection systems and methods, before establishing them. Another challenge rises from inadequate treatment of organizational support and ensuring internal adoption of developed systems (refers to all information systems). In bigger organizations this might have led to situations where there exist many concurrent and partly overlapping systems in different business units. From the point of view of the business units, the situation may be optimal, but from the whole company's point of view not.

It is quite obvious that it is not possible to name any single best system or method for all – best practices cannot be copied directly, but they need to be customized through organization-specific needs. There exist many working solutions where a set of methods integrated with processes and systems and used systematically may result in successful management of the activities in R&D project selection. Again, the appropriateness of the methods is closely related to practical needs, once clarified.

The evolution of information systems provides many possibilities to overcome the problems in R&D project selection. It is possible to develop 'transparent' systems that provide a means of integrating R&D project selection seamlessly to other company-wide information systems, and to provide the whole organization with an integrated innovation system that can be tailored to specific needs. Thus systematic support for the management of the early phases of innovation can be reached without losing its flexible nature. Taking the steps on the levels of IT support means an intensified need for management commitment and organizational support.

Transparency is related to the use of methods and the use of systems as well. Managers need effective and dependable support systems, and it is enough for them to understand the basics of the tools without a deep understanding of the logic of the systems or methods. It can be said that the methods are often used as techniques without understanding or ensuring proper support for their use. Support is important particularly in integrating methods as ingredients of decision making processes and systems. R&D project selection is a socio-technical decision making and management process. It incorporates people (individuals and groups), processes, systems, technology, methodologies, methods, data, and information. The use of different methods and systems can hardly be promoted without understanding the whole system.

*Role of Publication 4 in the thesis*

Publication 4 represents the systems and process perspectives of the thesis. It focuses on existing R&D project selection methods and complements the method list with strategic options thinking, which is a potential new approach for managing portfolios of ideas with a lowered level of risk. Further, it discusses the role and evolution of IT-supported tools in line with front end activities.

The main issue in the effective use of R&D project selection methods and systems is that they need to be designed for the organizational context of use. A careful assessment of the implementation patterns and recognition of activity bundles are needed, as there exists many methods and tools, and they are easy to design ad-hoc with the help of advanced IT[14].

### 6.5 Publication 5: Intranet-based system for the product innovation management process

*Objective*

The objective of Publication 5 is to build a system to promote product innovation management and support the use of management processes by using the possibilities of internet technologies. The system consists of a framework describing the components and functionality of the system, and of different process models for different kinds of projects. The process models are based on Cooper's stage-gate approach, and they support parallel implementation of different stages in product innovation processes. The system assists in the selection of an appropriate process model for projects, provides instructions for the implementation of the stages in the product innovation management process, and facilitates the documentation and document management in a distributed company environment.

*Main contribution*

The starting point for the design of the system is rooted in the earlier research of the success factors of new product development, where one of the main issues is that in order to have successful product innovations, a company needs high quality management processes. Further, it is an accepted fact that the management processes should be further developed, and are most often developed in firms on the basis of the practical problems of product innovation management, and particularly on the basis of clarified causes of the problems. Our earlier studies have clarified important product innovation management problems, their causes and defined development requirements for product innovation management (Koivuniemi et al. 1999, Piippo et al. 1998).

Publication 5 describes the developed system and clarifies its possibilities, advantages and limitations. The system supports the cooperation of different departments of the company in a geographically distributed environment, facilitates the management and control of the product innovation process at different working times and in different locations of individuals, and provides companies with a framework for building their own management systems. The system promotes controllability, systematics and risk management in product development. Flexibility and ease of use is supported with the inclusion of different types of channels and management models for different types of innovations supported with an innovation-type specific user interface. The main user interface for the intended system is a matrix of different types of projects (research, development/pre-studies, product projects) and size/urgency of the project. This type of multi-channel interface helps select the right management model for the project type from the very beginning.

Internet technology-based tools provide many possibilities for removing significant product innovation management problems. Within the developed system, the following features of internet technology-based tools are particularly beneficial: dissemination of critical organizational information embedded in projects and their data requirements, internal (intranet) and external

[14] Sub-optimal planning or "technological gimmicking" in innovation methods and tools can create a large amount of task-specific systems in a firm, which are not interoperable and are hence difficult to use from the perspective of providing procedural support for innovation management.

(extranet) document sharing, and enterprise-wide computing and decision support within projects. Internet and intranet technologies make it possible to build scalable and flexible systems that provide communication and collaboration support, as well as access to accurate information.

In sum, Publication 5 puts forward a framework and its Internet-based application to promote product innovation management and the use of management process models. The developed system integrates the process models and their instructions with tools helping in the implementation of the tasks defined in the process models. This makes the use of the process models easier and more useful, and motivates managers to actually adopt them. The developed system offers different kinds of process models and instructions for different kinds of projects and gives support in the selection of the correct process model. The system demonstrates the possibilities of the Internet for making the use of process models easier and more effective. The Internet-based system offers the same updated instructions for all persons participating in the development in different locations over the world and at different points in time. The newest information technologies (e.g. software agents, data mining, web-based product data management systems) provide powerful tools, which could be incorporated in the management of product development processes. A large number of applications and tools based on these technologies are already available through the Internet, and they could be connected to the product development management systems to make them more effective in terms of appropriate knowledge provided in the right place at the right time.

*Role of Publication 5 in the thesis*

Publication 5 represents the systems and process perspectives of the thesis. It connects the front end of innovation (in the system the term "preplanning" is used) to the overall product innovation management process at the project level. On the other hand it presents a combined model for management process control and project-level practical use of product innovation management systems. From the perspective of the user interface, the developed system provides a multi-channel model for innovation using the capabilities of Internet technologies. The system is an example of integrated product innovation management systems. In this case the integration is realized over different types of projects, and over critical project level activities in the lifecycle of a project.

### 6.6 Publication 6: A groupware tool for R&D project selection

*Objective*

The aim of this study was to develop a groupware tool for R&D project selection. The focus of the tool is on product development projects. The design parameter was set for the tool to cover the whole R&D project selection process[15] from idea gathering to the final analysis phase of ideas and innovations. The tool supports the cooperation of experts from different departments to synthesize their knowledge and to define the best projects in a distributed company environment.

*Main contribution*

R&D project selection is a group task, where different experts need to work together to collect ideas, to form a comprehensive definition of new product project proposals, and later on utilize their knowledge in the evaluation of projects[16]. The tool was developed on the basis of the problem-based approach. In the development process of the tool the problems of R&D project selection and

[15] See Appendix 1. Developed process model for R&D project selection.

[16] Following the idea of core competence and capability thinking, R&D project selection is an activity where various competence groups are needed, while the substance of the projects can vary considerably.

the challenges of a distributed environment were systematically transformed into the requirements of the tool. The tool was developed with the help of a formed process model, the features of the Analytic Hierarchy Process (AHP) and a groupware, Lotus Notes.

The tool includes four major modules: an information gathering module, a model structuring module, an evaluation module, and an analysis module. The main benefits of the developed tool are:

- Covers the whole R&D project selection process
- Supports continuous idea gathering
- Group discussion of ideas
- Supports distributed evaluation and decision making of R&D projects
- Supports comprehensive analysis of the project proposals
- Utilizes both qualitative and quantitative criteria in project evaluation
- Makes it possible to produce different decision hierarchies for different kinds of projects[17]
- Makes it possible to take business strategies into account in project evaluation and selection

The tool provides solutions for several problems in R&D project selection that especially distributed company environments face. The distributed, time independent use of the system is supported especially within the idea gathering and discussion module by allowing the users to add new ideas and comment on other ideas through a web browser. The tool covers the whole R&D project selection process from the idea phase to the final analysis phase and to the decision point of whether to carry out a project or not. The idea gathering, discussion, evaluation, and finally analysis are included in the same tool. The different modules of the tool can be used with the same user interface. The tool is linked to the whole R&D management process and can be used as one of the main management control systems within R&D.

*Role of Publication 6 in the thesis*

Publication 6 represents the systems and process perspectives of the thesis, with particular emphasis on the front end of innovation. Publication 6 presents a large system framework for the selection of R&D projects. In comparison to recent findings on the multi-channel model for innovation, the presented system provides means for building different types of evaluation frameworks on the basis of the requirements of different types of innovations. This feature makes the system framework usable in current R&D management of companies, even though the study was published already in 1999. Further on, the problem-based approach for the development of the tool provides a practical example of purposeful development of support systems for innovation management. Even though the problem-based approach might not lead to beneficial results as such, it encourages a firm to carry out a thorough analysis of the problem domain. This in turn provides a stronger basis for the development of enterprise-wide innovation management systems.

### 6.7 Publication 7: Toward internally and externally open front end of innovation

*Objective*

The underlying proposition for the study in Publication 7 is that a purposeful development and advancement of firm level mechanisms for innovation requires the definition of a broader architecture for innovation, to include innovation-critical internal and external business domains in the strategic context of a firm. It might also require fundamental changes in the underlying routines and mental models of innovation management at the early phases of the innovation process.

[17] This feature supports the multi-channel model for innovation and enables the adaptation of the evaluation module for any types of innovations.

Publication 7 constructs a framework for the internally and externally open front end of innovation. The constructed model takes into account internal and external mechanisms of multi-channel idea exchange to support effective channelling of innovative ideas through internal and external business domains, and the integration of knowledge around innovations. The framework also integrates industry level competitive trends and drivers to the idea processes to support the exchange of market and technology knowledge in order to generate new business opportunities, and to learn how to change innovation management models in the firm. The model is tested in a case context of a multinational firm operating in the pulp and paper industry, by analyzing its innovation management organization in three idea processes pertaining to the suggestion system, R&D unit and new ventures.

*Main contribution*

From the theoretical perspective, this study advances the understanding of the implications of the open innovation paradigm in the strategic context of a firm. The framework divides the firm-level innovation environment into externally open and internally open innovation environments. The internal dimension of open innovation is particularly advanced in the study by dividing it into structural, process, systems, and cultural openness. The open innovation paradigm expects firm-level innovation systems to become more open to external sources of knowledge and resources, enabling effective import and export of innovations and knowledge in any phase of the innovation chain. In our view, internally open innovation should be emphasized as well, as in many cases the barriers of innovation emerge from internal sources.

The practical contribution of the study relies on the defined framework for managing the early phases of innovation process in the open environment through effective use of idea management mechanisms in internal and external business domains. Firms can use the results of this paper to promote their organizations' inborn innovativeness through the purposeful development of idea management mechanisms towards different types of innovations and related strategies during the early phases of the innovation process. The construct of internally and externally open innovation helps identify the important targets for development towards more open-minded innovation management practices and culture.

While some of the idea processes can be business unit-specific, they still need to be integrated into the needed knowledge sources among other business domains, internally and externally. It can be argued that there might emerge an enforcing tendency towards closer inter-organizational integration of idea processes as new applications of open innovation paradigm are put into practice. As shown in Publication 7, firm-specific idea processes are opened up internally and externally even in traditional industries.

*Role of Publication 7 in the thesis*

Publication 7 represents the strategy and process perspectives of the thesis. It contributes to the definition of firm level innovation management strategies by combining a firm's internal innovation environment into its external business ecosystem. The competitive environment of a firm creates signals for changes in the innovation management practices and changes the contents and structure of idea processes at firm level. The developed framework also integrates industry-level competitive trends and drivers to the idea processes to support the exchange of market and technology knowledge for generating new business opportunities.

# 7 DISCUSSION AND CONCLUSIONS

The main purpose of this section is to assess the results of the thesis in relation to the original research questions, conclude the main contribution of the research, assess the validity of the results, describe the limitations of the thesis, and finally present ideas for further research.

The main objective of the thesis was that of enhancing the understanding about the management of the front end phases of the innovation process in the networked environment by combining the strategy, process and systems perspectives of innovation. In order to achieve the research objective, three research questions were formed:

- *Research question 1:* How are the purposes of R&D and innovation processes and innovation strategy linked in the context of a firm?
- *Research question 2:* How is the systemic framework for the front end of innovation formed in the networked operating environment of firms?
- *Research question 3:* How to provide innovation processes with appropriate systems support to promote the use of innovation management processes in firms?

The overall contribution of the thesis is formed by combining the results of the presented publications (Publication 1 – Publication 7) augmented with the new research material[18] provided in the introductory part of the dissertation. Following the baseline of the constructive research approach, the practical utility (managerial contribution and implications) and epistemological utility (theoretical contribution and implications) of the thesis are assessed, following with assessment of the judging criteria of qualitative research.

## 7.1 Managerial contribution and implications

Managerial contribution in line with Research Question 1

The generated list of purposes for the product development processes provide a basis for purposeful (read: strategic) development of innovation processes in firms. The relative importance of the purposes depends on the firm and its innovation strategy. The coverage of purposes emphasises the growing role of R&D by showing that new missions for it can be given. This approach was also supported by the Networked R&D Management approach. Applying the purposes as the guiding principle provides firms with a planned improvement programme for their innovation processes. The analysis of the purposes continued by adapting them for the front end phase of innovation. The potential use of purposes on this follows the usage pattern of the purposes for the PDPs. Respectively, the purposes at the level of the front end describe a broader mission for the front end phases of innovation.

The front end of innovation needs to be a flexible management process. Processes and ideas are different in type and nature. There is no generic best practice that would fit for the development and maturation of all types of ideas. The best practices can not be copied from outside as 'off the shelf' products. There is also a distinction between the effective practice for dealing with front end activities in connection with existing business and with business in the future. Also, the understanding of the dynamic and relative nature of customer value requires flexible and lean

[18] The introductory part of the dissertation includes some new research data and newly developed managerial frameworks, which were not available when writing the individual publications. The newly acquired data and developed frameworks are included to complement the coverage of the thesis.

structures to be used in the front end of innovation. Publication 4 discussed the different R&D project selection methods and systems. This information can be used when selecting appropriate methods for firms.

Managerial contribution in line with Research Question 2

Research question 2 is related mainly to the results presented in Publication 3. In the paper, the critical front end activities were described, and the front end was connected into the internal and external business domains of a firm. Some of the most critical building blocks of the front end can be summarized as follows: emphasis on single ideas in order to open up their potential, establishing alternate idea tracks, amalgamating ideas to the organization through various mechanisms, managing the portfolio of ideas, managing the linkages to critical knowledge and information sources, and managing the linkages to internal and partly external business processes.

Managerial contribution in line with Research Question 3

In this thesis, two system frameworks were developed to support the management process models for innovation. Both of the system frameworks are extensive; the first one (presented in Publication 5) covers basically the whole innovation process, and provides features of managing projects at different levels of completion. Also, it provides a platform for managing different types of innovations, and can be extended to cover all types of innovations. The second one, presented in Publication 6, provides a process model for R&D project selection process, as well as a supportive groupware-based system. Respectively, it provides an opportunity of generating different kinds of evaluation models for different types of innovations. For the portfolio management purposes it enables the use of any evaluation criteria as the dimensions of portfolio screens. In many other systems the portfolio views are fixed, and limit the use of information display. The groupware tool was realized with the help of Lotus Notes. The same system framework could quite easily be realized by other groupware platforms as well. While the design environment was a groupware platform, the developed R&D project selection tool serves as a distributed decision support system, where all members of the organization can participate in the innovation process in many roles (idea generator, commentator, evaluator).

It needs to be noted that IT tools have developed a lot during the years after the groupware tool for R&D project selection was constructed. This means that there exist more sophisticated systems and methods that can be used to realize the system. However, the developed system framework is adaptable, and can for this reason be implemented with the most advanced IT systems.

The following general findings can be concluded

- Innovation processes or procedures for handling radical innovation do not exist in firms (this means that the current strategy of the firm acts as a killer criterion for innovations)
- Open innovation practices are still rarely practiced, although some cooperative companies practise both internally and externally open innovation
- A multi-channel model for innovation is needed
- Not all strategically important issues are processed (“strategic anorexia”)
- Innovation processes still have a strong side-connotation related to fixed, rigorous, and systematic processes – a change in the mindset of employees is needed to understand the role of processes correctly
- Formal innovation processes are important, but they need to be complemented (informal processes) and built-in flexibility

- § Innovation and innovation processes are still regarded as the responsibility of certain units in many firms
- § Innovation processes need to be opened up to external sources of ideas, as well as external markets for ideas (idea banks can serve divergent and convergent purposes)

## 7.2 Theoretical contribution and implications

This thesis contributes to the growing field of research on the open innovation paradigm and its practical applications in the industry. This line of research is followed up by the evolution of innovation management practices and models in the industry towards more open interfaces and mutual collaboration, and stronger reliance on external knowledge and resources. This thesis distinguishes the internally open innovation environment and externally open innovation environment of firms. By doing that the thesis sets particular emphasis on the intra-firm interfaces that need to be managed to enable effective flow of ideas and innovations. A large part of the problems of innovation management are inborn. While the most advanced firms practice the open innovation, most firms still live in a more closed innovation management world. A combined internally and externally open innovation environment of firms creates bi-directional markets for ideas, both in the seeking of ideas and in their dissemination. An example of internal idea markets is the suggestion system, where the source and target of ideas is internal.

By combining the theories of competition to the front end of innovation, this thesis connects the early phases of innovation into strategic dialogue through different types of ideas and innovations. Through the developed systems constructs, this thesis illustrates potential implementation mechanisms of the multi-channel model for innovation within the same system framework. In many earlier models of firm level innovation processes, the idea processes are innovation type-specific and organization-specific. The presented list of various purposes for the innovation processes can be used as a structured way of developing firm level innovation management and processes.

## 7.3 Validity and quality of the research

**Credibility of the research** – The research was based on empirical data, where the main data sources were interviews, extensive literature reviews, firm-specific documents and publicly available firm level data. The interviews with firm representatives were documented, and used in variable roles in the different publications. The design of system frameworks was based on identified firm level problems of R&D and innovation management. The key terms of the research area were defined.

**Transferability of the research** – The developed system frameworks are adaptable to other operating environments and different types of innovations. A distinction should be made between the management process models and the system frameworks developed on the basis of these. Whereas the system framework is dependent on the IT environment in which it is realized, the management process model is more generally adaptable. Concerning the purposes of R&D processes and the front end of innovation, similar types of lists can be produced on the basis of literature and practical knowledge in other types of innovation processes. The conclusions made from particular firms and industries are not directly transferable to other firms and industries, because the firm and industry-specific conditions vary. The developed management frameworks can be used as a starting point for further research.

**Dependability of the research** – During the research process, careful documentation was carried out all the way. Several of the developed managerial frameworks and system frameworks were developed in cooperation with other colleagues to prevent a biased view of interpretations. Also,

representatives of the firms contributed to the developed frameworks, which is a sign of reliability. The article-based thesis enables the use of several research sub-processes for the purposes of different publications. From the perspective of dependability this makes the research process more flexible, but at the same time, it requires careful coordination of the whole research process. The overall objective of the thesis, and the defined research perspectives have guided the research and publication process. Compared to a monograph thesis, the consistency between the publications is not as high. This is normal in article-based theses. On the other hand, the article-based research process is more adaptable, and changes in the research plan can be made more flexibly if the underlying conditions change during the research process.

**Confirmability of the research** – The main issue in assessing the confirmability of the research is judging the sufficiency of the research process, and evaluating whether the research findings flow from the data. Concerning the sufficiency of the research process, the broad coverage of the thesis has clearly been a challenge. However, the thesis consists of seven publications, which all had their own objectives independently of the other publications. All publications had their own data and method as described in Table 6. It can be said that the research process has been task-oriented, where each of the publications is a sub-project of research. The publications as a whole, complemented with new data presented in Part I, answer the research questions of the thesis.

Qualitative research tends to assume that each researcher brings a unique perspective to the study. This notion causes that the interpretation of the data is partly dependent on the background and experience of the researcher. In each publication of the thesis, the research findings flow from the data (literature, firm-specific material, publicly available information), but are also subject to intuitive interpretation by researchers. The thesis relies on extensive literature studies, which enables the cross-checking between the findings and the data in referenced earlier research. The features and content elements of the developed managerial and system frameworks are largely based on empirical data collected from the firms, and documented in the form of interview transcripts.

### 7.4 Limitations of the thesis

This research has been carried out at the level of an organization or its processes and structures. This approach has had influence on the level of understanding of the mechanisms of the front end of innovation. An innovation project-level analysis would uncover more insightful issues which could be valuable in the understanding of the nature of innovation. On the other hand, the new understanding of the mechanisms and processes of innovation was carried out in this thesis by combining several perspectives of analysis (strategy, process, systems) in the networked operating environment of firms. By doing so the thesis has uncovered new important issues, as discussed in the connection with the managerial and theoretical contribution. Because of the clearly extensive focus area, some important streams of research were left outside this thesis. For instance, the organizing for innovation in the networked context was not in the focus. However, this topic is considered as important, and research is under way by a number of scholars on innovation management studies.

This research has been a qualitative study, which causes several limitations. The results are based on a limited number of case studies and clinical illustrations. For this reason the results should be interpreted with care, and too much generalization should be avoided. The developed system constructs, i.e. the intranet-based system for product innovation management and the groupware tool for R&D project selection, have been piloted ‘on-desk’. A longer term use in a real world company environment would bring about limitations that cannot be uncovered during a short time

of testing. However, after these constructs were developed, the same kind of features could be found in the firms' innovation management models. Some of the features are still novel after several years.

The thesis approached the networked environment from the point of view of the firm, e.g. instead of analyzing the innovation networks between firms. This causes limitations on the interpretation and application of results. The results presented in the thesis are mostly applicable at the firm level (not at a network level).

### 7.5 Suggestions for further research

Several important initiatives could be stated for continuing research on the basis of the findings of this study. Some topics for further research are listed below:

- Further operationalization and testing of the constructs in different industries, including
  - An intranet-based system for product innovation management
  - A framework for networked innovation management
- A study on the linkages between the purposes and performance of the innovation process
- Context-specific application of internally and externally open front end of innovation
- The complex concept of innovation management calls for further studies in defining innovation architectures in the strategic context of a firm
- Cognitive maps could be used to study the linkages between the purposes of the product development process, and also between the management concepts to enhance their applicability and usability in promoting companies' product development processes
- Research on the development of idea tracks for radical innovations outside the current strategy of a firm

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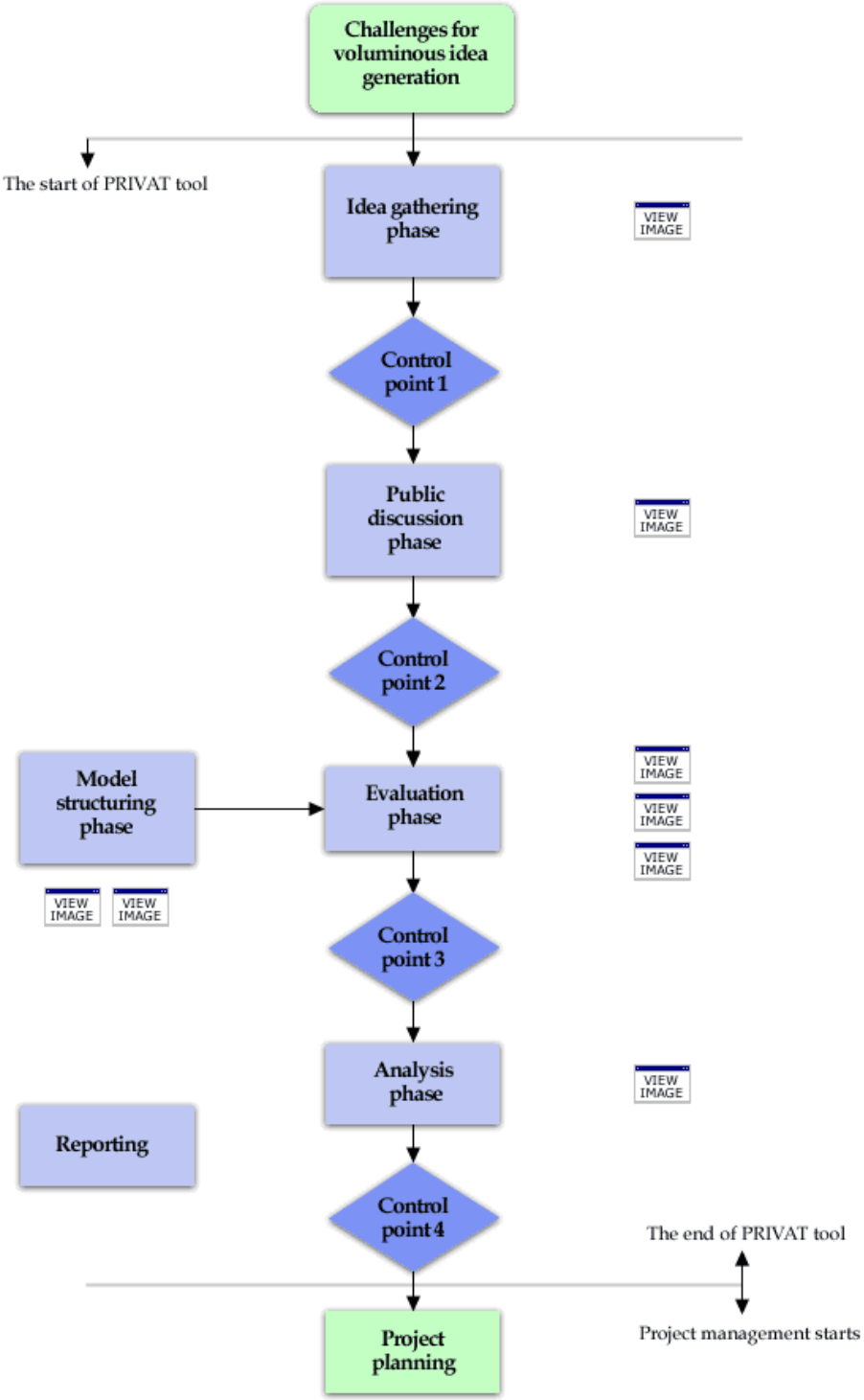
**Appendix 1. Developed process model for R&D project selection.**



**Appendix 2. Case study – Drivers of structural changes in pulp and paper industry.**

The case study is presented to illustrate the use of the developed framework for networked innovation management at strategic level (Source: Koivuniemi and Edelmann 2007).

The case study illustrates the use of the developed framework in analyzing several timely trends in the pulp and paper industry, which drive the structural changes in the industry. These trends include, relocation of pulp and paper production capacity in global scale, and changes in the end uses of paper, and the emergence of substitutes for paper. The potential implications to the innovation management and strategy of firms are presented.

The internal evolution and consolidation of pulp and paper industry has created several gigantic global firms (e.g. International Paper, UPM-Kymmene, StoraEnso). These firms compete with similar types of business models in the current mainstream pulp and paper production, which are based on large mill integrations, global operations and economies of scale. Competitive differentiation is difficult. Also, the pulp and paper industry is a capital-intensive industry, where entry barriers for new firms are high. On the basis of these issues we can say that the mainstream pulp and paper business is in the IO competition.

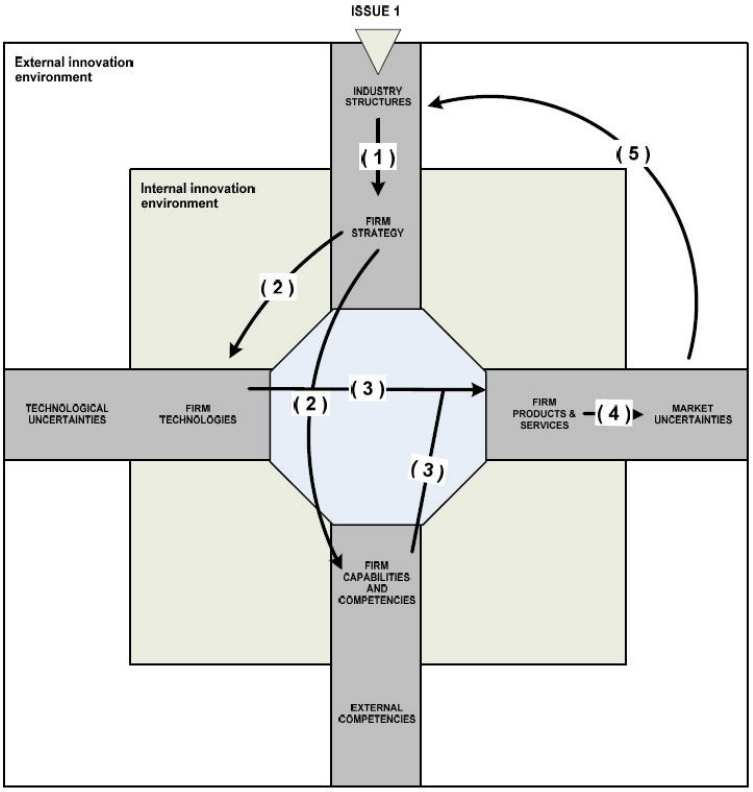
As the business models are very similar, competitive advantage is largely sought through operational effectiveness and productivity improvements. However, the profitability of the industry has constantly decreased during the last decades, and the growth (measured by net sales) has saturated in global scale (Source: annual reports). This situation has forced the firms to reconsider the locus of investments and relocate production. This is the entry point to our framework, and we can raise Issue (see figure next page).

In the framework, Issue 1 is presented as the starting point for analysis in the strategy dimension. There are several examples of strategic decisions (1; the numbers refer to the steps of analysis presented in the figure) on relocating pulp and paper production near new growth markets, and in countries with lower labour and raw material costs. For instance, Metsä-Botnia constructed a pulp mill in Uruguay, South-America, and StoraEnso has signed an agreement with Shandong Huatai Paper to form a publication paper company in China. When the production capacity is relocated, it also affects the location of other operations. For instance, UPM-Kymmene has founded a research centre in China.

Concerning the relocation of production, the core activities[19] and assets in the global scale are not under a threat. The question to be raised is related to the firm's technologies (2) in use and its existing capabilities (2). In this particular case, the firms can use their existing technology base (3) and existing capabilities (3), with no need to change them. The only new matter is the knowledge about making business in the eastern Asia. The end result of the above issues is that pulp, paper and board (4) are produced in geographically different areas, but no radical changes in the structure of the industry take place (5).

[19] The core activities are recurring actions that create value both by making the industry's suppliers more willing to transact and by generating greater willingness to pay among the industry's buyers. Core assets are durable resources that make the firm more efficient or effective at performing core activities, and can include intangibles such as brand capital and knowledge capital.

**ISSUE 1** – Relocation of production capacity and investments is on the way in pulp and paper industry firms in global scale, due to decreasing profitability and seek for growth markets.




The counter-effect of relocating production in new areas is the shutdown of unprofitable production units somewhere else. For national economies, such as Finland, which has a long successful history and heavy reliance on the pulp and paper industry (5 % from GDP and approximately one-fifth of the whole industrial production in Finland), the relocation of production is a tremendous threat. For smaller cities, which have arisen beside the mills, this can be a deathblow if nothing is done to compensate for the lost jobs. The potential counter-acts in one hand, and the changes in the end use of paper on the other hand, lead us to Issue 2 (see figure next page), and the Schumpeterian competitive environment.

Even if the relocation of pulp and paper production is targeted near the growth markets and cheaper raw material in China, India and Southern America, we may not expect the trends of consumption to follow the same paths as in the western countries. The expanding use of computers and emergence of electronic media have created some expectations for decreasing paper consumption, but so far the continuing growth in paper consumption has proved this expectation wrong. On the other hand, for instance the media industry is using electronic media instead of publication paper for advertising considerably more than earlier. In the western countries, where the ICT infrastructure is more advanced, a broader change to the use of electronic media is only a matter of time. In the long term, new technology-based solutions, like electronic paper, challenge the position of traditional print.

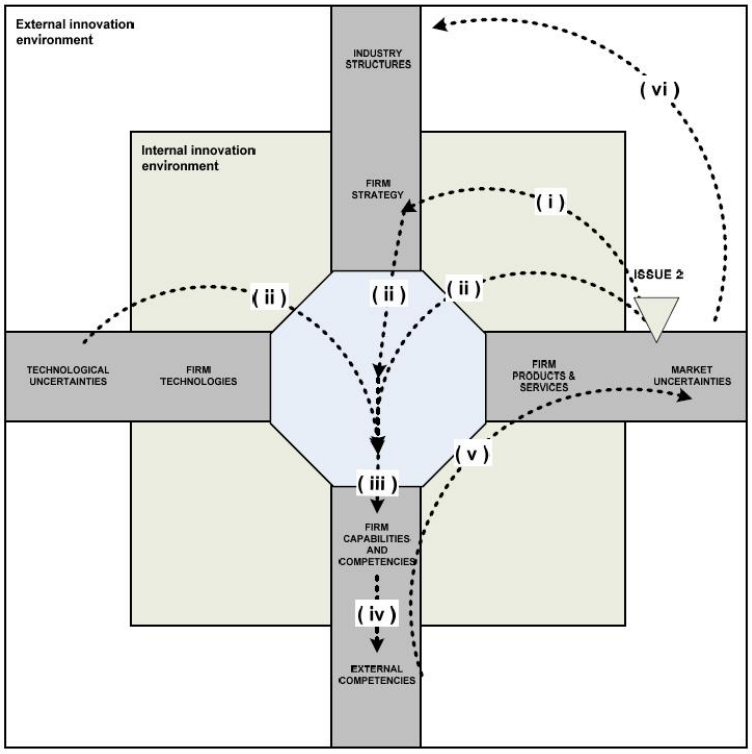
For the firms in the mainstream pulp and paper business, the above market trends provide also a possibility for distinguishing from their competitors and creating strategic advantage through innovation (i; the roman numbers refer to the steps of analysis presented in the figure below) – i.e.

to use strategies in the Schumpeterian competition. Technological uncertainty (ii) is higher, because there are several new opportunities emerging from digitalization (All-IP, ICT convergence, internet), biotechnology, nanotechnology, and applied material sciences. These are examples of the technological directions where the firms are going.

New types of competencies (iii) need to be acquired for new innovation-based competition, because the path-dependent evolution of industries has created the competencies and capabilities mainly around the mainstream pulp and paper business. Stronger networking is required to acquire complementary competencies (iv) and completely new competencies inside the firm. The broadened scope of technologies and new market related competencies can be used by firms to create unique competence and capability bundles, which are in the heart of Chamberlinian competition.

This also means that new types of mechanisms for innovation (i.e. innovation processes) need to be in place to be able to produce new types of innovations. The innovation capability of a firm would need to be broadened to new types of innovations, which would require the integration of knowledge from various technological and market areas, which were not earlier "on the table". For instance the focus of suggestion systems that have traditionally been in use for process improvements and related minor ideas in firms could now be developed towards an idea channel that enables seeking of new types of innovations. As the competence base of established firms is still strongly based on pulp and paper business, bi-directional idea channels should be opened up to network partners (e.g. technology providers, customers etc.) to boost the creation of new intersections of competence areas (e.g. new technologies) and expertise. We would expect this as an example of a quicker process of innovation-critical renewal in comparison to internally developed innovations.

**ISSUE 2** – Changes in the end use of paper and the emergence of substitutes for paper drive structural changes in the pulp and paper industry.



Next table presents some focal firm-level effects that apply to the strategic innovation management in the presented case.

| | | Types of competition | | |
|---|---|---|---|---|
| | | *Industrial organization economics* | *Chamberlinian competition* | *Schumpeterian competition* |
| *Source of competitiveness* | | Firm's position in the industry | Unique internal capabilities | Radical new innovations |
| *Focus of innovation strategy* | | Cost cutting, economics of scale and scope | Knowledge based competition; capability development | Innovation leadership |
| *Primary types of innovation* | | Process improvements; Process innovations; Product and service innovation | Organizational innovations; New (to the firm) business models | Radical innovations; Technology driven new business models |
| ***Case: pulp and paper industry*** | *Innovation capability* | Innovation and idea processes for incremental innovation (e.g. suggestion system) are emphasized to support continuous improvement. New product and service processes are important based on mainstream business priorities. Knowledge and learning processes rely on the "installed base" of technologies, resources and routines. | The focus of innovation processes is to find out new ways of organizing and develop new capability bundles based on existing internal competencies. The focus of knowledge processes is in the unique integration of internal competencies. Learning processes aim at finding new uses for internal capabilities. | Completely new innovation tracks are needed for radical innovations and new business models. Knowledge processes are linked strongly into new (to the firm) external sources of information. Learning processes constitute a large set of activities to foster future developments in markets and technology. |
| | *Strategy dimension* | Maintaining and strengthening the status quo of present strategy. Emphasis is on the global level in all operations (raw material supply, production, marketing). Reinforcing the positioning in the value chain. Management of current supply chain structures (supply side, partners, demand side). | Innovation and innovativeness emphasized as an enterprise-wide issue to create strong internal knowledge platform for innovation. New venture type of operations are important is seeking new uses for internal capabilities. | Focus is on the new stream innovation activities outside the current structures, processes, and strategy. Strategic option thinking focused so as to keep in touch with a large set of technological and market issues that might threat the industry. New innovations as a strategic tool for change. |
| | *Market dimension* | Reinforcing existing channels of marketing and selling within present products and services. Understanding customer present and future needs related to the use of paper and board products. Close cooperation with customer industries (e.g. packaging and print media). | Identification of new uses for present products, and development of service business besides tangible products. New external product and service areas become relevant if they can be related to current operations and products (e.g. RFID tags). | New potential substitutes (e.g. electronic paper and electronic media as a whole) for pulp, paper and board products create uncertainties. Emphasis on the future customer needs and changing structure of paper products consumption in global scale. |
| | *Technology dimension* | Maintenance of technology leadership in the base technology (the pulp, paper, and board production technologies). Strong linkages towards technology and machinery suppliers. Continuous hunt for effective use of installed technology base. Global sourcing of technology. | Seek for unique technology knowledge that can be related to current technology base. Technological know-how largely external on the supply side. Complementary technology partnerships in focus. | Completely new technologies in scope (nano technology, bio technology, ICT technologies). A major challenge is to manage a large scope of technologies that might challenge current products and services. Stronger external collaborative activities to learn from technology. |
| | *Capability dimension* | Continuous development of capabilities related to existing business, technologies and products. Influential linkages to educational institutions to ensure the supply of competent employees. Core competence thinking is emphasized and all non-core activities are outsourced. | Reinforcement of internal capability and competence base. Identification of the potential to develop distinguishing capabilities within the industry. | New capabilities needed basically in every area of business. Extremely strong reliance on external collaboration so as to identify future capability needs. |