

Helsinki University of Technology
Department of Industrial Engineering and Management
Doctoral Dissertation Series 2009/1
Espoo 2009

**INTER-ORGANIZATIONAL RELATIONSHIPS IN INNOVATION PROCESSES: A
MICROFOUNDATIONS APPROACH**

Mona Roman

Dissertation for the degree of Doctor of Science in Technology to be presented with due permission of the Faculty of Information and Natural Sciences, Helsinki University of Technology, for public examination and debate in Auditorium TU1 at Helsinki University of Technology (Espoo, Finland) on the 17th of April, 2009, at 12 noon.

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ISBN 978-951-22-9717-7 (print)
ISBN 978-951-22-9718-4 (electronic)

ISSN 1797-2507 (print)
ISSN 1797-2515 (electronic)

<http://lib.tkk.fi/Diss/2009/isbn9789512297184>

Cover photos: Conference locations (from left to right): Sydney, St. John's, Atlanta and Espoo.
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Multiprint Oy
Espoo 2009



ABSTRACT OF DOCTORAL DISSERTATION		HELSINKI UNIVERSITY OF TECHNOLOGY P.O. BOX 1000, FI-02015 TKK http://www.tkk.fi	
Author Mona Annika Roman (born Weck)			
Name of the dissertation Inter-organizational relationships in innovation processes: A microfoundations approach			
Manuscript submitted September 2 nd , 2008		Manuscript revised December 29 th , 2008	
Date of the defence April 17 th , 2009			
<input type="checkbox"/> Monograph		<input checked="" type="checkbox"/> Article dissertation (summary + original articles)	
Faculty	Information and Natural Sciences		
Department	Industrial Engineering and Management		
Field of research	Strategic Management		
Opponent	Dr. Ammon Salter		
Supervisor	Prof. Tomi Laamanen		
Instructor	Prof. Tomi Laamanen		
Abstract			
<p>Microfoundations have emerged as an important theme in strategic management research. The aim is to increase current understanding of many central issues of strategic management through studying organizations from the perspective of individual actions and interactions. This thesis takes the microfoundations approach to the study of inter-organizational relationships in invention and innovation processes. The key objective is to provide new insights about how to successfully utilize and manage inter-organizational relationships for new knowledge creation and exploitation. The main theoretical approaches used in the thesis are the resource-based view of the firm, the knowledge-based view and the social capital perspective. In addition to contributing to these theoretical approaches by adopting the microfoundations perspective, this thesis supports managerial practice in performing R&D collaboration.</p> <p>The thesis includes four individual publications, which are based on a case study approach. Publications I and II explore the role and nature of inter-organizational relationships in invention processes. They describe how inventors utilize external knowledge in the development of patents, and demonstrate the benefits of their external interactions for a firm as enhanced competitiveness and learning. As a key contribution, publications I and II reveal how inventors' informal interactions in R&D consortia and with suppliers and customers influence knowledge creation. The results are based on interviews with the inventors and a survey that covers 90 patent development processes in 1996-2004 in the case company that acts in the telecommunications sector.</p> <p>Publications III and IV examine managerial actions that contribute to successful implementation of collaborative R&D projects. Whilst prior research has determined the enabling conditions of successful knowledge creation and exploitation in inter-organizational relationships, publication III links these conditions with managerial actions such as the definition of clear project roles and responsibilities and customer education and training. These findings are derived from a case study of five collaborative R&D projects in the telecommunications sector. Publication IV examines how managers cope with project dynamics i.e. sudden changes that occur during a project. Earlier research has emphasized the importance of the topic, whilst it has been little studied previously. Publication IV develops a generic change management process for inter-firm R&D projects and assists in its implementation. These results are derived from a case study of two inter-firm R&D projects in the telecommunications sector.</p>			
Keywords Collaboration; innovation; inter-organizational relationships; knowledge; microfoundations; patent			
ISBN (printed)	978-951-22-9717-7	ISSN (printed)	1797-2507
ISBN (pdf)	978-951-22-9718-4	ISSN (pdf)	1797-2515
Language	English	Number of pages	84 p. + app. 44 p.
Publisher	TKK		
Print distribution Department of Industrial Engineering and Management			
<input checked="" type="checkbox"/> The dissertation can be read at http://lib.tkk.fi/Diss/2009/isbn9789512297184			



VÄITÖSKIRJAN TIIVISTELMÄ		TEKNILLINEN KORKEAKOULU PL 1000, 02015 TKK http://www.tkk.fi	
Tekijä Mona Annika Roman (o.s. Weck)			
Väitöskirjan nimi Organisaatioiden väliset suhteet innovaatioprosesseissa: Mikroperusteinen näkökulma			
Käsikirjoituksen päivämäärä 2.9.2008		Korjatun käsikirjoituksen päivämäärä 29.12.2008	
Väitöstilaisuuden ajankohta 17.4.2009			
<input type="checkbox"/> Monografia		<input checked="" type="checkbox"/> Yhdistelmäväitöskirja (yhteenveto + erillisartikkelit)	
Tiedekunta	Informaatio- ja luonnontieteiden tiedekunta		
Laitos	Tuotantotalouden laitos		
Tutkimusala	Strateginen johtaminen		
Vastaväittäjä	Tri. Ammon Salter		
Työn valvoja	Prof. Tomi Laamanen		
Työn ohjaaja	Prof. Tomi Laamanen		
Tiivistelmä Mikroperusteinen näkökulma on noussut tärkeäksi aiheeksi strategisen johtamisen tutkimuksessa. Tutkimalla organisaatioita yksilön toiminnan ja vuorovaikutuksen kautta tavoitteena on lisätä nykyistä ymmärrystä keskeisistä strategisen johtamisen kysymyksistä. Tässä väitöskirjassa hyödynnetään mikroperusteista näkökulmaa tutkiessa organisaatioiden välisiä suhteita innovaatioprosesseissa. Väitöskirjan tavoitteena on tuottaa uutta tietoa siitä, kuinka hallita menestyksekkäästi organisaatioiden välisiä suhteita uuden tiedon luomiseksi ja hyödyntämiseksi. Pääasiallisina teorioina väitöskirjassa on käytetty resurssi- ja tietopohjaista näkemystä yrityksestä sekä sosiaalisen pääoman näkökulmaa. Sen lisäksi että väitöskirja tuo uutta tietoa edellä mainittuihin teorioihin mikroperusteisella tutkimusotteella, se tukee yritysjohtoa tutkimus- ja tuotekehitysyhteistyön johtamisessa. Väitöskirja koostuu neljästä erillisjulkaisusta, jotka perustuvat tapaustutkimuksiin. Julkaisuissa I ja II tutkitaan organisaatioiden välisten suhteiden luonnetta ja merkitystä uuden tiedon luomisessa. Näissä julkaisuissa kuvataan kuinka keksijät hankkivat ja käyttävät yrityksen ulkoista tietoa patenttien kehittämiseen, sekä osoitetaan kuinka tämä ulkoinen vuorovaikutus edistää organisaation oppimista ja patentin luomaa kilpailuetua. Merkittävin löydös näissä julkaisuissa on keksijöiden epävirallisen vuorovaikutuksen standardointikumppanien, toimittajien ja asiakkaiden kanssa tärkeyden havainnollistaminen uuden tiedon luonnissa. Tulokset perustuvat keksijöiden haastatteluihin sekä kyselytutkimukseen, joka kattaa 90 patenttiin johtanutta kehitysprosessia tietoliikennealan yrityksessä vuosina 1996-2004. Julkaisuissa III ja IV tutkitaan projektijohdon toimia, jotka vaikuttivat yritysten välisten tutkimus- ja tuotekehitysyhteistyön menestykseen. Kun aikaisempi tutkimus on määrittänyt menestyksekkään organisaatioiden välisen tiedon luonnin ja hyödyntämisen ennakkovaatimukset, julkaisuissa III yhdistetään nämä ennakkovaatimukset projektijohdon toimiin kuten selkeiden projektiroolien ja -vastuiden määrittämiseen sekä asiakkaiden kouluttamiseen ja valmennukseen. Tulokset perustuvat tapaustutkimukseen viidestä tietoliikennealan yritysten välisestä tutkimus- ja tuotekehityshankkeesta. Julkaisussa IV tutkitaan projektijohdon toimia yllättävissä muutostilanteissa. Asian tärkeyttä on korostettu aiemmissa tutkimuksissa, mutta sitä on tutkittu vielä vähän. Julkaisussa IV kehitetään yleinen muutostenhallintatyökalu yritysten välisiin tutkimus- ja tuotekehityshankkeisiin. Tulokset perustuvat tapaustutkimukseen kahdesta tietoliikennealan yritysten välisestä tutkimus- ja tuotekehityshankkeesta.			
Asiasanat Innovaatio; tieto; organisaatioiden väliset suhteet; patentti; yhteistyö			
ISBN (painettu)	978-951-22-9717-7	ISSN (painettu)	1797-2507
ISBN (pdf)	978-951-22-9718-4	ISSN (pdf)	1797-2515
Kieli	Englanti	Sivumäärä	84 s. + liit. 44 s.
Julkaisija TKK			
Painetun väitöskirjan jakelu Tuotantotalouden laitos			
<input checked="" type="checkbox"/> Luettavissa verkossa osoitteessa http://lib.tkk.fi/Diss/2009/isbn9789512297184			

Preface

I have conducted this postgraduate research in the Department of Industrial Engineering and Management at Helsinki University of Technology during the years 2002-2008 alongside my work in the telecommunications sector. I am indebted to Helsinki University of Technology, my employer TeliaSonera and several research foundations that have supported me in realizing my PhD studies whilst working.

Many persons have supported me in the research process. First, I wish to thank my supervisor Prof. Tomi Laamanen for his continuous encouragement for scientific endeavours. Then, I would like to express my gratitude to my pre-examiners, Dr. Martin Meyer from Sussex University and Prof. Liisa Välikangas from Helsinki School of Economics, for their insightful and constructive comments. Furthermore, I am grateful to have Dr. Ammon Salter from Imperial College, London acting as my opponent in the public defence of my doctoral thesis.

My Master's thesis work at SimLab, Enterprise Simulation Laboratory, at Helsinki University of Technology laid essential ground for my PhD work. I am grateful to Prof. Riitta Smeds for leading me to the study of inter-organizational R&D processes. During the years Prof. Kirsimarja Blomqvist from Lappeenranta University of Technology has been significant support for me in PhD research. She is my co-author in two conference papers and in one journal paper, which I gratefully acknowledge here. Moreover, I wish to thank Associate Prof. Annaleena Parhankangas from New Jersey Institute of Technology for her important advice in regard to the survey research and Prof. Markku Maula from Helsinki University of Technology for his comments in the early phase of my PhD research. Also, I am grateful to my co-students, Dr. Henri Schildt and Mikko Jääskeläinen, for their help and support. The institute administrators, Maria Tikka, Nina Henriksson and Salla Määttä, and the department library staff, Jaana Vuopala, Leena Mellavuo and Annikki Huttunen, deserve also many thanks.

I wish to thank my superiors in TeliaSonera, Riku Österman, Henri Harmia, Annika Christiansson, Michael Grant, Christina Lundman-Lagerstedt and Mia Bengtsson, for their interest and support towards my PhD research. Moreover, I wish to thank my

colleagues at TeliaSonera for their interest in my studies along these years. Finally, I am indebted to the R&D management and employees in all the case companies studied for providing their invaluable insight to this research.

This research has benefited of financial support from the Academy of Finland (decision 105318, project 203977), the Finnish Doctoral Program in Industrial Engineering and Management, the Jenny and Antti Wihuri Foundation, the Emil Aaltonen Foundation, the Finnish Foundation for Technology Promotion, the Research and Training Foundation of TeliaSonera Finland Oyj, the Finnish Cultural Foundation, and Marcus Wallenberg's Foundation for Research on Business Economics. I am grateful for all this support which has enabled me to focus on several periods for full-time PhD research. Moreover, I wish to thank the Foundation for Economic Education for supporting my participation in an international conference organized by the Strategic Management Society in Orlando, Florida in 2005.

Finally, I wish to express my warmest gratitude to my parents Tor-Ulf and Armi for all their encouragement, support and practical advice throughout the PhD process. I also wish to thank my brother Jan and his family as well as my grandmother Irene for being there. Foremost, my special thanks go to my husband Timo for his understanding and love during these years. As being a Dr. himself and an inventor behind a number of patents, he has also been able to support me in both topic-related substance matters and practical issues in this research.

Contents

Preface	i
Contents.....	iii
List of Figures	v
List of Tables.....	vi
List of Publications	vii
Part 1: Theoretical background and key findings.....	1
1 Introduction.....	3
1.1 Background.....	3
1.2 Research questions	5
1.3 Research methods and data	10
1.4 Key definitions	12
1.4.1 Inter-organizational relationships.....	12
1.4.2 Innovation	13
1.4.3 Patent development process	14
1.5 Structure of the thesis	15
2 Literature review	16
2.1 Theoretical perspectives on knowledge creation.....	16
2.1.1 Resource-based view.....	17
2.1.2 Knowledge-based view	19
2.1.3 Social capital perspective.....	22
2.1.4 Open innovation paradigm.....	23
2.1.5 Comparison of perspectives underlying the thesis topic.....	28
2.2 Literature related to the specific research questions of the thesis	30

2.2.1	Inter-organizational relationships in knowledge creation and learning	30
2.2.2	Alliance developmental processes and the dynamics of cooperation	41
3	Summary of individual publications	51
3.1	The role of inter-organizational relationships in the development of patents: A knowledge-based approach	51
3.2	Search-transfer behaviour, knowledge heterogeneity and organizational learning	53
3.3	Knowledge creation and exploitation in collaborative R&D projects: Lessons learned from success factors	54
3.4	Coping with project dynamics in an inter-firm project context	55
4	Key contributions of the thesis	57
4.1	Contributions to literature	57
4.1.1	The role and nature of inter-organizational relationships in the development of patents	58
4.1.2	The importance of informal inter-organizational relationships	59
4.1.3	The impact of individual-level interaction in the patent development process on patent competitiveness and learning	60
4.1.4	Managerial actions for successful implementation of collaborative R&D projects	61
4.1.5	The development of generic change management process for inter-firm R&D projects	63
4.2	Managerial implications	65
5	Limitations	67
6	Conclusions and future studies	69
	References	71
	Part 2: Original publications	Error! Bookmark not defined.

List of Figures

Figure 1. Differences in the scope of individual publications	7
Figure 2. Knowledge flows in an open innovation paradigm (Chesbrough, 2003)	25
Figure 3. Nature of inter-firm ties enabling open innovation (Simard and West, 2006)	26

List of Tables

Table 1. Research questions	7
Table 2. Comparison of perspectives underlying the thesis topic	29
Table 3. Overview of prior studies on the impact of inter-organizational relationships on innovation and learning	35
Table 4. Factors contributing to the success of collaborative R&D (Tidd et al., 2005).	42
Table 5. Overview of prior studies on alliance evolution and the dynamics of cooperation	47
Table 6. Summary of individual publications	56

List of Publications

This thesis consists of an overview and of the following publications which are referred to in the text by their Roman numerals.

- I Weck, M., Blomqvist, K., 2008. The role of inter-organizational relationships in the development of patents: A knowledge-based approach. *Research Policy* 37, 1329-1336.*
- II Weck, M., 2005. Search-transfer behavior, knowledge heterogeneity and organizational learning. In *Proceedings of IEEE International Engineering Management Conference, IEMC 2005, St. John's, Canada*, pp. 822-826.
- III Weck, M., 2006. Knowledge creation and exploitation in collaborative R&D projects: Lessons learned on success factors. *Knowledge and Process Management* 13, 252-263.
- IV Weck, M. 2005. Coping with project dynamics in an inter-firm project context. *Production Planning & Control* 16, 396-404.

* This publication has two authors. In the following, a short description is provided to explicate the author contribution. I, Mona Roman (born Weck), have, as the first author of publication I, come up with the idea to this paper. I have designed the research setting, conducted the interviews and the survey study within the case company. I have analyzed the results and prepared the first version of the paper. The second author, Prof. Kirsimarja Blomqvist at Lappeenranta University of Technology, has commented draft versions of this paper and suggested improvements in the text. As the first author, I have edited this paper and developed its final version based on review and editorial comments of *Research Policy*.

Part 1: Theoretical background and key findings

1 Introduction

1.1 Background

Microfoundations have emerged as an important theme in the field of strategic management in the 2000s. Strategy scholars are claiming that as a consequence of open markets and hypercompetition, sustainable competitive advantage lies increasingly in the micro assets of organizations that are hard to discern and awkward to trade (Johnson et al., 2003). These micro assets are invisible in traditional strategy research, which has focused on the macro level of organizations (Argote and Ingram, 2000; Bouty, 2000; Felin and Foss, 2006; Johnson et al., 2003). The microfoundations approach that examines organizations on the level of individual action and interaction has great potential to enhance strategy research in many central issues such as organizational learning, knowledge transfer, innovation and competitive advantage (Felin and Foss, 2006).

This thesis utilizes the microfoundations approach as a lens to study inter-organizational knowledge creation. The theoretical perspectives used in this thesis are the resource-based view of the firm (RBV), knowledge-based view (KBV) and social capital perspective. These theoretical perspectives have been selected as they are central perspectives in the study of knowledge creation in the field of strategic management. They have many similarities with each other as they all emphasize resources as the source of competitive advantage of firms. Whilst the resource-based view considers all types of resources, the knowledge-based view focuses on knowledge-based resources and the social capital focuses on relational resources. The main objective of the thesis is to provide new insights into the above mentioned theoretical perspectives through studying how individuals within organizations manage inter-organizational relationships for successful knowledge creation and exploitation.

The resource-based view has been criticized in the field of strategic management as providing a too static view of the phenomena. For this reason, it is unable to explain

how valuable resources are built and how they generate superior returns (Priem and Butler, 2001). It has been argued that theoretical development also within the knowledge-based view and the social capital perspective would require more analyses about processes that underlie resource creation and utilization and about the role of individual action and interaction in this process (Felin and Foss, 2006; Nahapiet and Ghoshal, 1998; Priem and Butler, 2001; Spender and Grant, 1996). In order to improve current understanding, the microfoundations approach has been selected in this thesis to study inter-organizational knowledge creation.

The first two publications in this thesis explore the role and nature of inter-organizational relationships in invention processes from the perspective of individual inventors. Even though earlier research has extensively demonstrated the link between inter-organizational relationships and the number of patents (e.g., Ahuja, 2000; Dutta and Weiss, 1997; Shan et al., 1994; Stuart, 2000), we know little about the underlying inter-organizational knowledge exchange processes in the development of patents. The main data source in publications I and II are interviews with the inventors behind the patents and a survey of 90 patent development processes in the case company. As a key contribution, publications I and II describe how the inventors' informal interactions in R&D consortia and with suppliers and customers significantly contribute to firm-level outcomes of patent competitiveness and learning. These informal relationships have been invisible in prior macro level studies that have utilized secondary data sources such as alliance databases.

The last two publications in this thesis examine the management of collaborative research and development (R&D) projects. Prior research has argued that the mere existence of relational resources is not enough, but these relationships must be managed and renewed to capture the underlying value (Johnson et al., 2003). Indeed a large proportion of inter-firm collaborations fail to achieve their goals despite the great potential that they entail (Doz, 1996; Gulati, 1998; Khanna et al., 1998; Lunnan and Haugland, 2008). Publications III and IV provide in-depth analyses of managerial actions that contribute to successful implementation of collaborative R&D projects. These studies examine collaborative R&D projects from the microfoundations

perspective. Whilst prior research has determined the conditions of successful knowledge creation and exploitation in inter-organizational relationships, publication III links these conditions with managerial actions such as the definition of project roles and responsibilities, communication to all project interfaces and a customer-oriented approach, as well as customer education and training. These findings are derived from a case study of five collaborative R&D projects with customers in the telecommunication services sector.

Publication IV examines how managers cope with project dynamics, i.e. sudden changes that derive from inside or outside the project. While prior research has found change management to be challenging in inter-firm collaborations, few studies have addressed the issue. Even the project management literature has not yet fully covered the management of project uncertainty (Ward and Chapman, 2003). Publication IV develops a generic change management process for inter-firm R&D projects and applies it in two cases of inter-firm R&D projects. As its main result, it shows how environmental and change-specific issues affect the implementation of a generic change management process in inter-firm R&D projects.

1.2 Research questions

This thesis has as its overarching aim an examination of the management of inter-organizational relationships for successful knowledge creation and exploitation in invention and innovation processes. The purpose is to provide new insights into the phenomenon through the study of individual actions and interactions. The research approach was motivated by the call for microfoundations to increase our understanding of micro-level dynamics through which resources are developed, renewed and managed (Felin and Foss, 2006; Johnson et al., 2003). This type of approach is valuable in linking content and process issues together (Johnson et al., 2003). So far, content and process studies have formed separate research tracks in the field of strategic management (Nerur et al., 2008).

The thesis focuses on the empirical domains of inter-organizational relationships and invention/innovation processes. Prior research has demonstrated in numerous studies that inter-organizational relationships contribute to innovation performance, typically measured as the number of patents (e.g. Ahuja, 2000; Dutta and Weiss, 1997; Shan et al., 1994; Stuart, 2000). These prior studies of inter-organizational relationships have mainly been at the organizational level (Becheikh et al., 2006; Felin and Foss, 2006; King and Anderson, 2002; Oliver and Ebers, 1998). This situation exists despite the fact that it is individuals who have ideas, define problems, and perform creative linkages and associations that lead to inventions (Trott, 2002). Studying knowledge at the level of individual interactions has been suggested to potentially bring important new information to existing organization-level explanations on knowledge creation (Argote and Ingram, 2000; Felin and Foss, 2006).

Publications I and II address different aspects of the overarching research aim than publications III and IV. Whilst publications I and II examine the role of inter-organizational relationships in patent development processes from the perspective of inventors, publications III and IV focus on the management of inter-organizational R&D projects from project manager perspective. Figure 1 illustrates the key differences in the research scope of publications I and II in relation to publications III and IV.

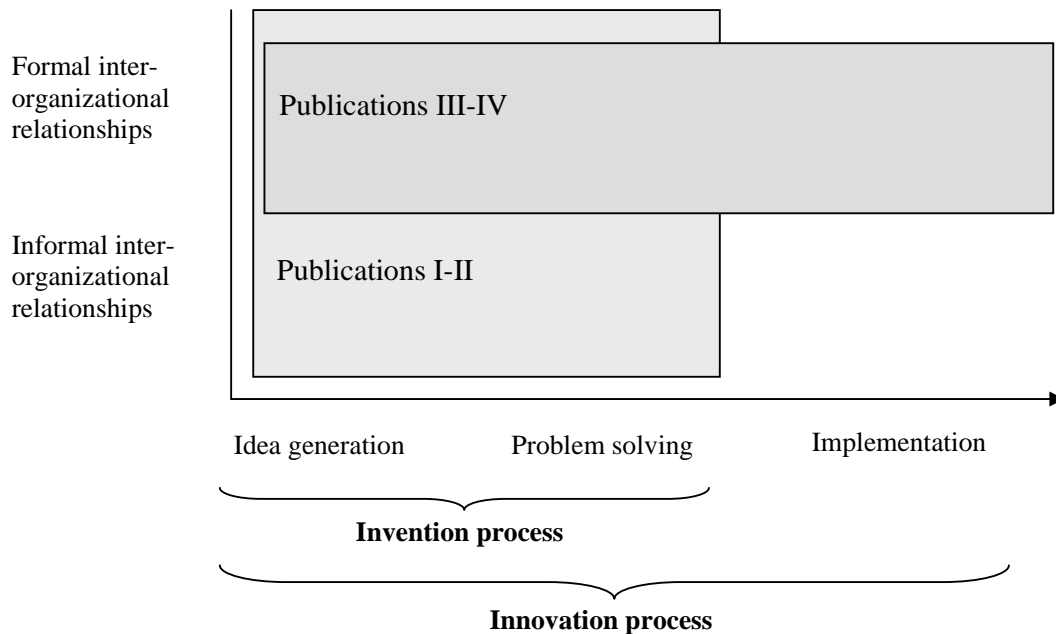


Figure 1. Differences in the scope of individual publications

Table 1 presents the detailed research questions, which is followed by a short description of the key motivation behind these questions.

Table 1. Research questions

How do individuals manage inter-organizational relationships for successful knowledge creation and exploitation in invention and innovation processes?

Publications I and II: Role of inter-organizational relationships in the development of patents

- How do inventors acquire and utilize external knowledge in the process of patent development?
- How does inventors' external interaction contribute to firm-level outcomes - patent competitiveness (I) and learning (II)?

Publications III and IV: Management of inter-organizational R&D projects

- Which managerial actions contribute to successful knowledge creation and exploitation in collaborative R&D projects? (III)
- How should managers cope with project dynamics in the context of inter-firm R&D projects? (IV)

Q1: How do inventors acquire and utilize external knowledge in the process of patent development?

As prior studies on patenting have mainly been conducted at the organizational level utilizing information present in patent documents, they have not been able to sufficiently cover the real extent of collaboration in the invention process (Giuri et al., 2007). Prior literature on open innovation has urged more individual level studies in order to increase our understanding of how knowledge is acquired and utilized inside the firms as well as on the role of informal inter-organizational relationships in the creation of new knowledge (Simard and West, 2006; Vanhaverbeke, 2006; Vanhaverbeke and Cloudt, 2006). Publications I and II adopt a broad definition of inter-organizational relationships that covers both formal and informal inter-organizational relationships. They examine the role and nature of inter-organizational relationships in the creation of new knowledge from the perspective of individual actions and interactions. Publications I and II aim at contributing to the strategic management field with new insights about the role and nature of inter-organizational relationships in the process of patent development.

Q2: How does inventors' external interaction contribute to firm-level outcomes - patent competitiveness and learning?

Prior studies have typically examined innovation performance according to easily available, quantitative measures such as patent counts (Hagedoorn and Cloudt, 2003). Moreover, patent citations and patent classes have been used to measure the scope of learning in the context of innovation. This is despite prior research having revealed limitations in using patents and patent citations as outcome measures (Giuri et al., 2007; Griliches, 1990). Spender and Grant (1996) emphasize that success in patenting does not necessarily correspond to success in translating patents into competitive advantage. Several authors have urged improvements to the current measurement of innovation performance (Grant, 1996a; Simard and West, 2006).

Publication I and II utilize qualitative measures based on the assessment of inventors in regard to the patent competitiveness and learning implications. They relate inventors' external interactions in the patent development process directly to these firm-level measures. This type of approach enables the examination of causality between individual interactions and firm-level outcomes (Felin and Foss, 2006; Johnson et al., 2003).

Q3: Which managerial actions contribute to successful knowledge creation and exploitation in collaborative R&D projects?

Prior research into the knowledge-based view and the social capital perspective have identified a number of enabling conditions for successful partnerships such as motivation to collaborate, trust and knowledge combination capability (Anand and Khann, 2000; Lane and Lubatkin, 1998; Nahapiet and Ghoshal, 1998). There have been few studies on the management of ongoing collaborative R&D projects and especially on how to implement the enabling conditions in practice (Doz, 1996; Gerwin, 2004). Recently, Lunnan and Haugland (2008) urged future studies in strategic management to provide a deeper understanding of how partners' manage initial adaptations and handle developmental processes in successful alliances. Publication III is based on a case study of five collaborative R&D projects that feature both successful and unsuccessful projects in order to reveal how managers can, through their actions, contribute to the implementation of successful collaborative R&D projects. Publication III contributes to the knowledge-based view and social capital through linking the conditions of successful knowledge creation and exploitation with actual managerial actions.

Q4: How should managers cope with project dynamics in the context of inter-firm R&D projects?

Prior literature has focused on how to carry out large, influential change initiatives, while the management of project dynamics that is influenced by sudden changes during an ongoing inter-firm project has received little attention. This is despite that prior

literature emphasized continuous learning and adaptation of initial project conditions to be important success factors of collaborative projects (Doz, 1996). Moreover, change has been considered so far as a risk in the project management literature. Such a viewpoint induces a restricted view of the management of project uncertainty (Ward and Chapman, 2003). Publication IV addresses the issue of how to cope with project dynamics in order to take advantage of positive change and to minimize the potentially negative consequence of change such as increased project cost and time. It develops a change management process for inter-firm R&D projects and tests its applicability through two case studies on collaborative R&D. Publication IV contributes to the resource-based view through new insights into, and tools for, the management of change in collaborative R&D projects.

1.3 Research methods and data

This chapter introduces the research methods and data used in this study. A more detailed description is provided as part of the individual publications, which are presented at the end of the thesis. This thesis adopts the microfoundations approach as a lens to study the phenomena through individual level actions and interactions (Felin and Foss, 2006; Johnson et al. 2003). This approach focuses on analyzing the dynamics of micro level phenomena. This thesis considers the phenomena in terms of activity, events, change and temporal evolution. This type of process-oriented approach has been encouraged to be used more in strategic management research (Langley, 2007). This is important as many areas within strategic management research have tended to be explained in terms of the outcomes of what goes on in an organization, rather than the activities that constitute them (Johnson et al. 2003). One advantage of linking the process and content issues is moreover that the results are readily applicable to managerial practice (Johnson et al., 2003).

The generic research method in this thesis is a case study approach. Case studies are commonly used for understanding the dynamics present within single settings

(Eisenhardt, 1989). They utilize extant theoretical approaches for constructing theoretical frameworks and very tentative, generic hypotheses (Flynn et al., 1990). The strength of a case study approach is its ability to generate novel, precise and empirically valid theories, but as a weakness the results are often narrow and idiosyncratic (Eisenhardt, 1989). In order to improve the generalization of research results, the research focused on examining activities that commonly underpin and explain competitive advantage such as the transfer of knowledge. Such an approach identifies particular events and actions that can contribute more generally and has been claimed to be appropriate for increasing the generalizability of case studies (Johnson et al., 2003; Langley, 2007).

The case company in publications I and II is a large telecommunication operator in Finland. Primary data was collected through interviews and a survey of the inventors behind patents in the case company. The survey study includes data on 90 patent development processes in the case company in the period 1996-2004. These data were analyzed both qualitatively and quantitatively. They were structured according to the source of external knowledge, the role and nature of inter-organizational relationships in different phases of the patent development process, patent competitiveness and learning outcomes. This structure supported the search for cross-case patterns, i.e. the similarities and differences among different patent development processes. The systematic structuring of case data enhances the process of building accurate and reliable theory based on a case study (Eisenhardt, 1989). Moreover, data triangulation was used for producing a richer understanding of the role and nature of inter-organizational relationships in the development of patents, and also to enhance the reliability of the data. First, several expert interviews were conducted with R&D managers and patent engineers in the case company with respect to the patenting policies and the process of patent development. Second, 13 interviews with the inventors were carried to understand the role and nature of inter-organizational relationships in the development of case company patents. Last, a survey of 90 patent development processes was used to evaluate statistically how widely such relationships were utilized and what influence they had on patent competitiveness and the scope of learning inside the case company.

Publications III and IV are case studies of collaborative R&D projects in the Finnish telecommunications sector. In order to ensure the reliability of the research, these studies followed carefully the guidelines of case research (Eisenhardt, 1989; Voss et al, 2002). Publication III includes five case studies of collaborative R&D projects between a telecom operator and its customers and, in addition in some cases, its partners. These projects feature both successful and unsuccessful collaborations in order to be able to identify key events and issues that separated successful projects from unsuccessful ones. The primary data were collected in this study through six interviews with project participants in April-June 2004 and through direct observations in project meetings of one collaborative case project in April-June 2002.

Publication IV was based on two inter-firm R&D projects between a telecom equipment manufacturer and its vertical partners in the value chain. The primary data were collected through 15 interviews with project participants in February-June 2001 and in two business process group simulation sessions. A business process simulation is a suitable method for process improvement and innovation (Smeds, 2003; Smeds and Alvesalo; 2003). The research data in publication IV was analyzed through a systematic comparison of two case projects in regard to the key changes that occurred during the collaborative R&D projects and the management of these change situations.

1.4 Key definitions

1.4.1 Inter-organizational relationships

This thesis views organizations as social entities that are goal-oriented, deliberately structured activity systems with an identifiable boundary (Daft, 1992). In regard to inter-organizational relationships, this thesis makes a clear distinction between formal and informal inter-organizational relationships. Informal inter-organizational relationships involve adaptable arrangements in which behavioral norms rather than contractual obligations determine the contributions of parties (Smith et al., 1995). They

are loosely coupled relationships in which firms may have little common purpose or agenda (Golden and Dollinger; 1993). For instance, informal relationships may feature close working relations with suppliers and customers (Trott, 2002). In this thesis, informal inter-organizational relationships are defined as non-contractual inter-organizational relationships in which individuals from different organizations interacting together may have little common purpose or agenda. Formal inter-organizational relationships in turn are defined here as contractual agreements between different organizations to work together to achieve joint goals.

Publications I and II in this thesis examine both formal and informal inter-organizational relationships. In other words, Publications I and II cover in addition to alliances and partnerships, also infrequent and casual interactions between R&D employees from different organizations that contributed to successful knowledge creation in the patent development process. Publications III and IV focus on formal inter-organizational relationships. They feature in specific inter-firm R&D collaborations that have been defined in original publications as “voluntary agreements between firms involving exchange, sharing or co-development of products, technologies or services” (Gulati, 1998).

1.4.2 Innovation

Whereas invention is the act of creating an idea for a new product or process, innovation involves the development of a commercial product from invention (Schumpeter, 1934). The following simple equation is commonly used to show the relation between the two terms: $Innovation = invention + exploitation$ (Roberts, 1997). Inventions are necessary seeds for innovation, but inventions do not always lead to innovation (Trott, 2002).

Publications I and II examine invention processes and the specific context of patent development. They focus on the two first phases of generic innovation process, i.e. idea generation and problem-solving. Publications III and IV cover, in some cases, all phases

of the innovation process. All the studied projects aimed at the implementation, but in some cases the projects were in fact postponed or terminated due to various reasons.

1.4.3 Patent development process

Publications I and II examine how the inventors of the case company patents generated the idea behind the patent and developed it to the technical solution underlying the patent. These activities are referred to as a patent development process or an invention process. The main focus is on the examination of knowledge flows between the inventor and his/her internal or external stakeholders and how the acquired external knowledge contributed to idea generation and problem solving. The problem solving refers here to the process of developing an idea to a technical solution that inventor described in a firm-internal invention report. The patent development process is defined in this thesis to end when the inventor submits an invention report. The work of case company patent board, which makes the final decision on whether or not the company will apply for a patent based on the invention report, or that of the patent engineer who prepares a patent application are outside of the scope of this thesis. This thesis thus focuses on the creative patent development process in which the inventor is at the centre of activities. It does not examine the work of the patent engineer in which patent protection is sought for one invention, which can involve several patents.

Since the entire process from an application to the granting of a patent can take between two and five years (Schilling, 2005), the sample of patents in publications I and II include both patent applications and granted patents. Including patent applications that had occurred close to the research period was important in order to be able to get detailed descriptions from the inventors with respect to the activities of a specific patent development process.

1.5 Structure of the thesis

This thesis consists of two parts. Part 1 presents theoretical background and key findings in chapters 1-6, which serve as introduction to the original publications. Chapter 1 provides an introduction to the topic, research questions, methods and data, key definitions and the structure of the thesis. Chapter 2 presents the theoretical perspectives used in the thesis and a literature review of key empirical research related to the specific research questions. Chapter 3 provides a summary of individual publications. Chapter 4 highlights the key contributions and chapter 5 outlines limitations in the thesis. Chapter 6 closes the first part with conclusions and suggestions for future research. Part 2 presents, at the end of the thesis, the original publications.

2 Literature review

This literature review provides an overview of the theoretical perspectives underlying the thesis topic. Section 2.1 presents an introduction to these theoretical perspectives and to open innovation paradigm. Section 2.2 describes the extant literature and its limitations that are related to the specific research questions of the thesis.

2.1 Theoretical perspectives on knowledge creation

The following sections describe theoretical perspectives used in this thesis. These include the resource-based view and its extensions to the knowledge-based view (Grant, 1996a, Spender and Grant, 1996) and social capital (Nahapiet and Ghoshal, 1998). These perspectives were selected in this thesis as they are central perspectives in the study of knowledge creation in strategic management field. In order to keep the theoretical foundations of the thesis simple and manageable, the thesis focuses on only these three theoretical perspectives. This is despite that there are also other related theories available in the extant literature on organizations such as organizational learning theory and evolutionary theory.

The resource-based view focuses on examining ‘the inside of a firm’, which is also central in this thesis. The theoretical perspectives used in the thesis emphasize resources as the source of competitive advantage for the firm. They see inter-organizational relationships valuable in the creation of new resources as well as in the combination of existing resources in novel ways and thus to contribute to innovation development. The knowledge-based view and social capital are especially relevant for the thesis, as these perspectives emphasize knowledge to reside in individuals, whilst the thesis examines knowledge creation and exploitation from the perspective of individuals in organizations.

This section also provides an introduction to the open innovation paradigm. It briefly presents key concepts of the open innovation paradigm and its limitations. Open innovation paradigm is central piece of recent literature on innovation. Open innovation paradigm is important for the thesis, as it provides an explanation on the growing role of inter-organizational relationships in today's global economy. Finally this section ends with an overall comparison of the three theoretical perspectives and the open innovation paradigm.

2.1.1 Resource-based view

Key concepts and underlying assumptions

Interest in internal firm characteristics re-emerged in the 1980s in the strategic management field as a necessary step for studying competitive dynamics and boundary relationships between the firm and its environment (Hoskisson et al., 1999). The aim was to unravel the inner structural logic and functioning of firms and thus to shed light on the notion of classical management theories that viewed firms as a sole production function (or 'black box') (Hoskisson et al., 1999). The resource-based view of the firm sees firms as a bundle of resources that defines its competitive position. Resources can consist of physical, human and intangible assets of the firm. The basic assumptions of RBV are resource heterogeneity and resource immobility, which enable resources to become a source of competitive advantage for firms (Barney, 1997).

The basic question of RBV is why some firms outperform others, although all of them compete in the same environment that basically provides the same opportunities. RBV originates from the work of Penrose, who tried to understand how firms grow and what the limits were of a firm's growth. Penrose (1959) emphasized the need to analyze firms as administrative frameworks that link and coordinate activities of numerous individuals and groups. While traditional economists had focused on just a few resources that might be inelastic in supply, Penrose began to study, inter alia,

managerial teams, top management groups and entrepreneurial skills, and found there to be an additional source of heterogeneity (Barney, 1997). Penrose (1959) suggested that the growth of a firm was limited by the bundle of its productive resources and by the administrative framework used to coordinate the use of those resources.

RBV was not popularized as a distinct theoretical approach before the 1990s. The term resource-based view was introduced by Wernerfelt (1984), who urged firms to pay more attention to the nature of their resources and resource fit with product-market strategies. Prahalad and Hamel (1990) argued that the real sources of competitive advantage are found in management's ability to identify core competences out of corporate-wide technology and production skills. Barney (1991) indicated that resources and capabilities that are valuable, rare, imperfectly imitable and non-substitutable provide competitive advantage for the firm. Since 1990's, RBV has become one of most influential perspectives in strategic management field. In fact, Barney's (1991) paper 'Firm resource and sustained competitive advantage' was the most cited article in the strategic management literature in the period of 1980-2005 (Furrer et al., 2008).

Main limitations

One central limitation of RBV derives from its inaccurate definitions of basic concepts and their interrelationships, which make it difficult to validate empirically (Priem and Butler, 2001). Thus, law-like relations, which are essential for theories, cannot be formed for RBV (Priem and Butler, 2001). Moreover, RBV has been criticized for not qualifying as a 'theory of the firm', because it does not address the question why firms exist and what determines their size and scope (Conner, 1991).

Some researchers have claimed that while RBV focuses on the 'inside of firms', it still regards processes as black boxes (Doz, 1996; Lawrence, 1997). RBV should clarify how resources are actually obtained, combined and utilized for competitive advantage (Priem and Butler, 2001). Barney (2001) raised the issue that future RBV needs to incorporate behavioral phenomena of choice and implementation in its models. Similar

to this, Felin and Foss (2006) argued that while prior research has indicated that performance differences between firms derive from heterogeneous resources, competences or capabilities, it has virtually not referred to the role of individual action and interaction influencing the formation of these capabilities.

2.1.2 Knowledge-based view

Key concepts and underlying assumptions

The focus on knowledge as the principal source of competitive advantage emerged in the strategic management literature in the 1990s. Spender and Grant (1996) argued that strategy research had concentrated on content rather than on the ‘manner of knowing or learning it’. The theoretical roots of the knowledge-based view are in the knowledge-centered approaches of Penrose, Arrow and Hayek, which have been enriched by contributions from evolutionary economists, Nelson and Winter, and epistemologists, Polanyi (Spender and Grant, 1996). There are also several similarities between KBV and organizational learning theory, as they both have been influenced by evolutionary theories and, subsequently, view firms as a repository of knowledge (Nelson and Winter, 1982; Spender, 1996).

Grant’s (1996a) paper ‘Toward a knowledge-based theory of the firm’ is among most influential work in strategic management literature (Furrer et al., 2008). In this paper Grant (1996a) defines critical characteristics of knowledge for its utilization to consist of transferability, capacity for aggregation and appropriability. First, knowledge is difficult to transfer between organizations due to its tacitness, context specificity and complexity, which enable knowledge to provide a source of competitive advantage (Galunic and Rodan, 1998; Grant, 1996a; Kogut and Zander, 1992). Polanyi (1983) explained tacitness of knowledge by referring to people knowing more than they can tell. Second, knowledge aggregation requires knowledge recipients to have the ability to value, assimilate and utilize knowledge. This ability is also known as absorptive

capacity (Cohen and Levinthal, 1990). Last, knowledge is inappropriable by means of market transactions, except for patents and copyrights where knowledge owners are protected by legal property rights (Grant, 1996a).

Grant (1996a) in his seminal work on the knowledge-based theory of the firm emphasizes knowledge as residing within individuals, and that the primary role of the organization is knowledge application. As individuals have a limited capacity to acquire, store and process knowledge, they need to specialize in knowledge acquisition (Grant, 1996a). The reason why firms exist is that they can create conditions under which individuals may integrate their specialist knowledge. In another paper, Grant (1996b) further developed KBV by defining the primary mechanisms for firms to integrate knowledge through direction and organizational routines. He described organizational routines as better for integrating knowledge since the conversion of tacit knowledge into explicit knowledge, in the form of rules and directives, may involve substantial knowledge loss.

Prior research has presented organizational knowledge creation as an evolutionary cyclical process where external stimuli (competitors' initiatives, normative changes and scientific discoveries) are combined with internally generated information (Kogut and Zander, 1992; Nonaka and Takeuchi, 1995; Zollo and Winter, 2002). Recently, Grant and Baden-Fuller (2004) proposed knowledge accessing, in addition to knowledge acquisition, to be a key mechanism through which organizations may benefit of inter-organizational relationships. According to Grant and Baden-Fuller (2004), knowledge accessing increases the knowledge specialization of firms, while knowledge acquisition increases the knowledge base of the firm. The authors argue that knowledge-accessing alliances are suitable for complex and fast-moving industries, as they increase the efficiency of knowledge application.

Main limitations

The knowledge-based view, similar to the resource-based view, sees firms as the ‘creators of the positive’, rather than as ‘avoiders of the negative’ (Conner, 1991). While they both have included the concept of asset specificity from transaction cost economics, they have nonetheless overlooked the concept of opportunism (Conner, 1991). The knowledge-based view thus provides an insufficient explanation for the existence of a firm, but it complements transaction cost economics, e.g. in regard to the organization of innovation activities (Foss, 1996).

KBV has also been criticized for insufficient consensus about its analysis and predictions (Grant, 1996a). The intangible, complex and multidimensional nature of knowledge-based resources makes their empirical examination difficult (Spender and Grant, 1996; Nonaka and Nishiguchi, 2001). Much of the earlier work on knowledge-based resources has focused upon R&D expenditure as inputs to knowledge creation and patent counts as output, although the success at patenting does not necessarily correspond to success in translating patents into competitive advantage (Spender and Grant, 1996).

KBV has been mostly studied at the level of organizations, while several authors claim that analyses at the level of individual action and interaction would benefit theory development (Argote and Ingram, 2000; Felin and Foss, 2006). Future studies should examine the critical questions of the individual-level foundations of knowledge and origins of the capabilities developed (Felin and Foss, 2006). Property rights and appropriation, i.e. who creates and owns new value, and who captures that value is one of important areas to consider in future studies that take the microfoundations approach (Felin and Hesterley, 2007).

2.1.3 Social capital perspective

Key concepts and underlying assumptions

The concept of social capital originates from sociological theory (Moran, 2005; Portes, 1998). The work of Granovetter (1985) proposed most behavior to be embedded in networks of inter-personal relations. He emphasized inter-organizational relationships to be beneficial in the search for new knowledge, as they are more likely to provide novel and non-redundant knowledge than intra-organizational relationships (Granovetter, 1973). Coleman (1988, p. 5) introduced the concept of social capital that “unlike other forms of capital inheres in the structure of relations between actors and among actors”.

Nahapiet and Ghoshal (1998) essentially brought social capital in the centre of strategic management literature in the late 1990s. Their paper on social capital has since become one of the most influential in strategic management research (Furrer et al., 2008). Nahapiet and Ghoshal defined social capital as the sum of actual and potential resources embedded within, available through, and derived from the network of relationships possessed by an individual or social unit. They emphasized social capital to contribute to organizational advantage through supporting the creation of intellectual capital in organizations. Nahapiet and Ghoshal (1998) defined key dimensions of social capital to consist of structural, relational and cognitive dimensions. The structural dimension refers to the location of actors’ contacts in a broader structure of social interactions. The relational dimension refers to the assets rooted in social relations such as trust and trustworthiness. The cognitive dimension is embodied in attributes like shared codes or languages that foster common understanding in a social relation. These dimensions of social capital influence resource exchange and combination between actors. Several empirical studies have demonstrated that social capital is positively related to the creation of new intellectual capital and fosters organizational learning (e.g. Bouty, 2000; Rodan and Galunic, 2004; Subramaniam and Youndt, 2005; Tsai and Ghoshal, 1998).

Main limitations

Social capital has been criticized as an umbrella concept, since there are important differences between scholars in regard to its concepts and definitions (Adler and Kwon, 2002; Dean and Kretschmer, 2007). Moreover, the terms intellectual capital and human capital have been criticized as misleading, because they fail to account that knowledge and ideas are constantly being transformed through individual and organizational learning processes (Dean and Kretschmer, 2007). Maurer and Ebers (2006) have argued that social capital literature lacks a dynamic view on how organizations' social capital develops over time e.g. which factors and processes enable and constrain its development.

Indeed, Nahapiet and Ghoshal (1998) have urged future research to examine process dynamics related to knowledge exploitation, as they see that it is not sufficiently covered in the existing social capital framework. While the social capital framework of Nahapiet and Ghoshal is on the organizational level, it has been also argued that future research needs to clarify how individual-level social capital influences firm-level performance (Moran, 2005). Moreover, Maurer and Ebers (2006) argue that future research should devote more attention to studying in-depth with whom actors connect, and to which resources they can thereby potentially gain access.

2.1.4 Open innovation paradigm

Key concepts and developments

The open innovation paradigm follows a series of earlier developments in innovation process models. It argues that post-war innovation models can be essentially characterized as 'closed innovation' paradigm, as these models emphasize firms to develop and generate ideas internally into new products or businesses (Vanhaverbeke, 2006). The first 'technology push' model developed in the 1950s viewed internal R&D

as a source of innovation, whilst the second 'need-pull' model emphasized the role of marketing as a source of innovation (Rothwell, 1992). These models were followed by the 'coupling' model that highlighted the importance of communication between R&D, manufacturing and marketing in the innovation process. The fourth 'integration' model emerged in the 1980s to present innovation first time as a largely parallel process (Rothwell, 1992). This model also emphasized that innovations occur as the result of interaction in the marketplace, the science base and the organization's capabilities (Trott, 2002). The fifth 'systems and networking' model emphasized the accelerating process of innovation, facilitated by IT-based networking.

'Open innovation' paradigm was essentially developed to respond to the increasingly interconnected nature of the global economy in the 2000s (Chesbrough, 2006). For instance, the increasing costs and complexity of R&D, shortening of technology life cycles, presence of increasingly knowledgeable suppliers and customers, growth of venture capital and growing diffusion of leading-edge knowledge in worldwide universities and research laboratories laid ground for the growth of inter-organizational relationships and the emergence of the open innovation model (Vanhaverbeke, 2006).

The 'open innovation' model treats R&D as an open system. It highlights that the innovation process can be initiated from both internal and external sources and that new technology can enter into the process at various stages. Open innovation model also emphasizes opportunities related to intellectual property, as inventions can go to market in many ways such as through licensing, technology spin-offs and the company's own sales and marketing channels at different stages in the innovation process. Figure 2 illustrates knowledge flows in open innovation process (Chesbrough, 2003).

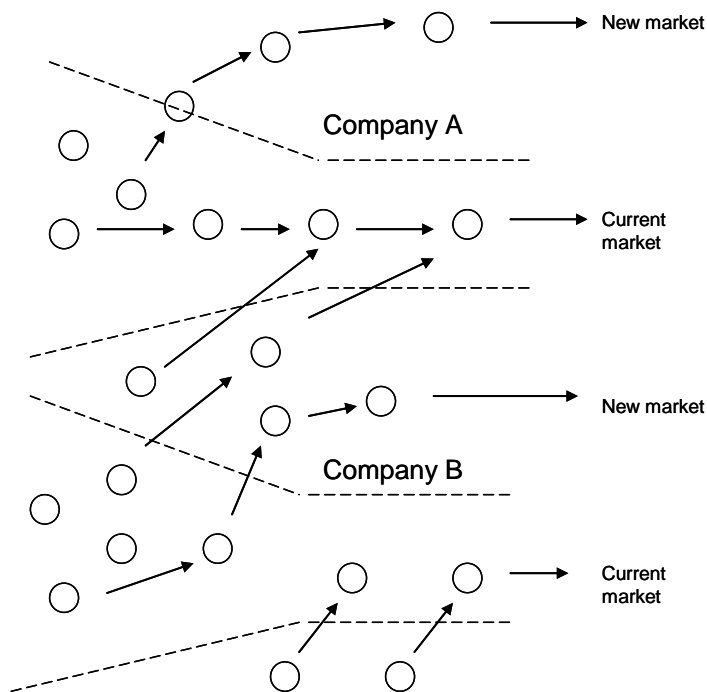


Figure 2. Knowledge flows in an open innovation paradigm (Chesbrough, 2003)

Open innovation paradigm sees the role of internal R&D to identify, understand, select from, and connect to, the wealth of available external knowledge and to fill in the pieces of knowledge that are missing from external developments (Chesbrough, 2003). The inter-organizational relationships are essential in all parts of the innovation process. They provide access to complementary skills, scale benefits and a broader knowledge base, and thus contribute to innovation development (Simard and West, 2006). Wide relationships are more difficult to initiate and coordinate than deep relationships, but they contain higher innovation potential due to their non-redundant knowledge. Informal ties are only to be recognized and utilized at the level of individuals, whilst formal ties are easily recognized at the level of organization. Figure 3 presents the typology of inter-organizational relationships that enable open innovation (Simard and West, 2006).

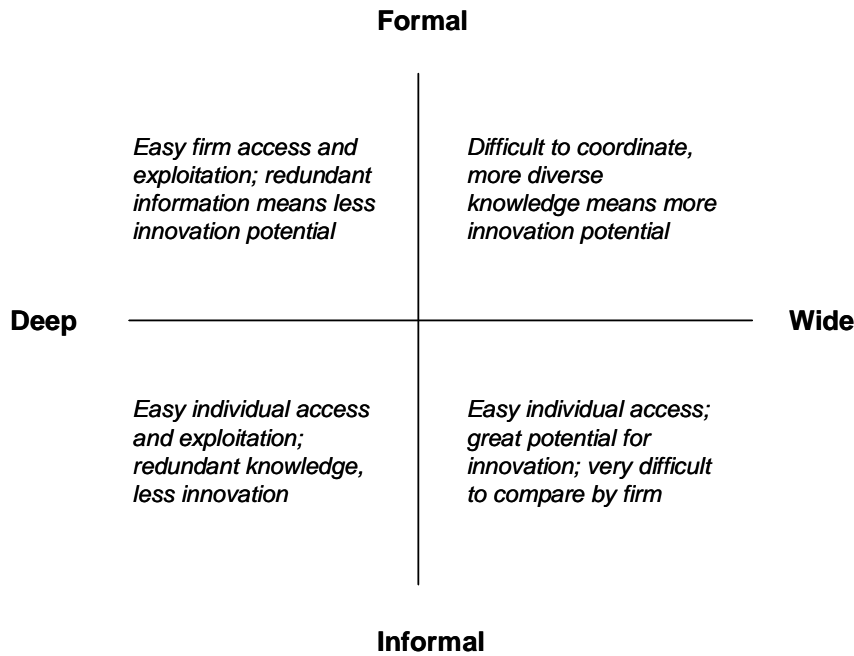


Figure 3. Nature of inter-firm ties enabling open innovation (Simard and West, 2006)

The open innovation model brings new challenges to motivate R&D personnel to incorporate relevant external knowledge with the firm's resources and capabilities and to contribute to external knowledge (West and Gallagher, 2006). The management needs to ensure the careful scanning of external knowledge and to develop an internal capability to integrate that knowledge inside the firm (West and Callagher, 2006). Moreover, they need to articulate clearly the benefits of the open innovation model to R&D personnel in order to overcome the Not Invented Here (NIH) syndrome (Chesbrough and Crowther, 2006). The management also needs to ensure that incentives for innovators remain the same even when they share their knowledge with external stakeholders (West and Callagher, 2006).

Limitations of open innovation literature

Most of the open innovation literature has focused on organizations as the unit of analysis (Vanhaverbeke and Cloudt, 2006; Chesbrough, 2006). As many firms struggle to leverage external innovations, it should be important to analyze in more detail how a firm's internal organization plays a role in improving the assessment and integration of externally acquired knowledge (Vanhaverbeke, 2006). Future research should analyze open innovation at the individual or unit level (Vanhaverbeke and Cloudt, 2006).

Open innovation studies have typically studied the role of formal inter-organizational ties, whilst the role of informal ties is less well understood (Simard and West, 2006). Informal ties comprise those ties utilized by a firm's employees in a way that may not be visible when looked at from the organizational level (Simard and West, 2006). Simard and West (2006) urge future research to examine how informal ties can be utilized for accessing commercially valuable knowledge.

Measurement of innovation creation and flows has also been challenging also in open innovation literature. Patent counts cannot reveal the commercial value related to inventions as the propensity to patent varies greatly across industries (Simard and West, 2006). Moreover, prior research has commonly utilized patent citations to measure knowledge flows between firms. Studies that have correlated patent citations to self-reported knowledge flows suggest that one of these measures is imprecise (Jaffe, 2000). Recent research indicates that patent citations cannot sufficiently track knowledge flows between organizations as they are typically added by patent engineers when filing the patent, i.e. once the invention has been developed (Giuri et al., 2007). Future research is thus needed to improve the measurement of knowledge flows in innovation process and the value of innovations (Simard and West, 2006).

In sum, earlier literature has identified the following limitations in open innovation literature: 1) the lack of studies on the individual or unit level, 2) the lack of studies on informal inter-organizational relationships and 3) the lack of precise measures of knowledge flows in innovation process and the commercial value of innovations. These

limitations are also common for other empirical work that has examined inter-organizational relationships in the context of knowledge creation.

2.1.5 Comparison of perspectives underlying the thesis topic

There are many similarities between the resource-based view, the knowledge-based view and the social capital perspective, as they all view resources as a main source of competitive advantage for firms. They emphasize the importance of inter-organizational relationships in the creation of new resources and in the combination of existing resources. Whilst the resource-based view examines all types of resources, the knowledge-based view focuses on knowledge-based resources and social capital on relational resources. The open innovation paradigm emphasizes the growing importance of inter-organizational relationships and external knowledge throughout the innovation process. Table 2 provides a comparison of the theoretical perspectives used in the thesis in regard to their main arguments, scope and relevance for the thesis.

It has been argued that the theoretical development of the resource-based view, the knowledge-based view, social capital and open innovation would require analyses about processes that underlie resource creation and utilization. Future studies should cover the processes and practices that constitute the day-to-day activities of organizational life and which relate to strategic outcomes (Johnson et al., 2003). The extant strategic management research seems to take organizations for granted, thus forgetting that organizations are made up of individuals, and there is no organization without individuals (Felin and Foss, 2006). There is need to explain the individual-level origins, or microfoundations of collective structures such as routines and capabilities (Felin and Foss, 2006). This is the type of research that has potential to bring new insight into the current organization-level explanations (Felin and Foss, 2006). Studying individual action and interaction is also important for increasing the current understanding on informal relationships that enable open innovation (Simard and West, 2006). The present thesis has adopted the microfoundations approach in order to bring new insight

into the extant theoretical perspectives in regard to how individual actions and interactions in organizations contribute to successful knowledge creation and exploitation.

Table 2. Comparison of perspectives underlying the thesis topic

	Main arguments	Scope	Relevance for the thesis
Resource-based view	<ul style="list-style-type: none"> ▪ Resources provide competitive advantage ▪ Growth of the firm is limited by the bundle of its productive resources and administrative framework used to coordinate these resources 	<ul style="list-style-type: none"> ▪ Firm internal resources ▪ Mostly examined at organizational level 	<ul style="list-style-type: none"> ▪ Provides a framework to identify firm's resources that provide competitive advantage ▪ Emphasizes that resources must be managed to capture the value inherent in resources.
Knowledge-based view	<ul style="list-style-type: none"> ▪ Knowledge-based resources provide competitive advantage ▪ Knowledge resides within individuals, and the primary role of the organization is the integration of specialist knowledge 	<ul style="list-style-type: none"> ▪ Firm internal knowledge-based resources ▪ Typically aggregated on organizational level 	<ul style="list-style-type: none"> ▪ Emphasizes individuals as primary source of knowledge ▪ Identifies key characteristics of knowledge, transferability, capacity for aggregation and appropriability, which influence its utilization ▪ Provides a framework on organizational knowledge creation ▪ Identifies mechanisms of inter-organizational knowledge transfer and learning
Social capital	<ul style="list-style-type: none"> ▪ Relational resources provide competitive advantage ▪ Relational resources facilitate resource exchange and combination, which enable the creation of intellectual capital 	<ul style="list-style-type: none"> ▪ Relational resources ▪ Typically aggregated on organizational or unit level 	<ul style="list-style-type: none"> ▪ Provides a framework on organizational knowledge creation ▪ Provides a framework to identify structural, cognitive and relational dimensions of social capital that facilitate the creation of intellectual capital
Open innovation	<ul style="list-style-type: none"> ▪ R&D is an open system ▪ Inter-organizational relationships are important throughout the innovation process. They provide access to complementary skills, scale benefits and a broader knowledge base and increase opportunities to profit from innovation 	<ul style="list-style-type: none"> ▪ Innovation process ▪ Typically examined at organizational level 	<ul style="list-style-type: none"> ▪ Describes the growing role of inter-organizational relationships in the global economy ▪ Provides a typology of inter-organizational relationships that enable open innovation (formal vs. informal ties; deep vs. wide ties)

2.2 Literature related to the specific research questions of the thesis

The following sections focus on prior literature that is closely related to the specific research questions of the thesis. The section 2.2.1 provides an overview of literature on the sources of innovation and knowledge creation mechanisms as well as the impact of inter-organizational relationships on learning and innovation. This literature is closely related to the topic of publications I and II of the thesis. The section 2.2.2 examines prior literature on success factors in alliances and partnerships, alliance evolution and the dynamics of cooperation. This literature is closely related to the topic of publications III and IV of the thesis. At the end of both sections, the limitations of prior literature are discussed. The research questions of the thesis have been selected to overcome many of these limitations in prior literature.

2.2.1 Inter-organizational relationships in knowledge creation and learning

Sources of innovation and knowledge creation mechanisms

Prior literature has explained knowledge creation as a cyclical process in which organizations combine external stimuli with internally generated information (Kogut and Zander, 1992; Nonaka and Takeuchi, 1995; Zollo and Winter, 2002). The external environment both supplies stimuli and substance that can be used to improve existing organizational routines. It also provides feedback on the value and viability of the organization's current routines (Zollo and Winter, 2002). The organizational knowledge creation can be seen as an evolutionary process in which organizational exploration and exploitation activities contribute to the development of organizational capabilities (Zollo and Winter, 2002). The main modes of the knowledge creation are socialization, externalization, combination and internalization (Nonaka, 1994). The knowledge

creation consists of these spiral phases in which organizational members share tacit knowledge, convert it to explicit knowledge, combine the explicit knowledge of each other and learn through action when explicit knowledge develops into tacit knowledge.

Organizations that choose collaborative learning strategies, which involve high transparency and receptivity, are likely to learn most together in a partnership (Hamel, 1991; Larsson et al., 1998). If no organization is transparent, no existing knowledge is disclosed and thereby cannot be received by the others or used collectively to generate new knowledge - nor can transparency be utilized without the receptive ability and motivation to absorb the disclosed or generated knowledge (Larsson et al., 1998). Moreover, prior research has demonstrated that integrating learning mechanisms, as opposite to institutionalizing mechanisms, enhance alliance portfolio performance (Heimeriks et al., 2007). The integrating mechanisms occur when knowledge is shared between individuals in a group, whilst institutionalizing mechanisms transfer group knowledge to organizational level. The integrating mechanisms contribute to the creation of capabilities. The institutionalizing mechanisms in turn embed routine behaviour and capabilities in systems, processes and structures, which tend to make practices rigid and difficult to adjust (Heimeriks et al., 2007).

Prior literature on innovation management has emphasized customers, suppliers and universities as important sources of innovation (Trott, 2002; Tidd et al., 1997; Tushman, 1977; Utterback, 1971; von Hippel, 1988). Successful inventors have been shown to utilize multiple sources of information and ideas including: 1) in-house R&D; 2) linkages to customers or other potential users of innovations; 3) linkages to external network of competitors, complementors and suppliers; and 4) linkages to other external sources of scientific and technical information such as universities and research institutes (Schilling, 2005). Both formal and informal external interactions have been found to provide the opportunity for thoughts, potential ideas and views to be exchanged and shared (Trott, 2002). The proactive search for technical and market inputs, as well as receptivity to information gained from external sources, are critical aspects of technology-based innovations (Roberts, 1997). The accumulation of

knowledge and the effective assimilation and application of this knowledge distinguishes innovative firms from their less successful counterparts (Trott, 2002).

The impact of inter-organizational relationships on innovation and learning

The literature on the impact of inter-organizational relationships on innovation and learning builds on e.g. Powell et al. (1996), Walker et al. (1997), Shan et al. (1994), Stuart (1998), Stuart et al. (1999) and Ahuja (2000). This literature has grown rapidly along with the high growth of partnerships especially in high-tech industries (Hagedoorn, 2002). The development of alliance databases improved the ability of researchers to examine the phenomena statistically from the 1990s. For instance, systematic collection of inter-firm alliances started in 1987 in the CATI (Cooperative Agreements and Technology Indicators) information system (Hagedoorn and Shakenraad, 1994).

The early studies on alliances and partnerships showed that patent intensive corporations are heavily involved in strategic partnering (Hagedoorn and Shakenraad, 1994). In fact, cooperative agreements were demonstrated in several studies to enhance the rate of patenting e.g. in biotechnology (Shan et al., 1994) and chemicals sector (Ahuja, 2000). Powell et al. (1996) argued that locus of innovation is found in the networks of learning in industries in which the knowledge base is both complex and expanding. Powell et al. (1996) based this finding in the study on biotechnology firms in 1990-1994 that showed the firm's centrality in a network of relationships and experience at managing ties at a given time to enhance its growth rates.

One of the early research topics was to examine the impact of alliance network structure on the formation of alliances and the subsequent innovation. This work built on Gulati's (1995b) study on 'social structure and alliance formation', which demonstrated that high strategic interdependence of firms increases their likelihood to form alliance. Gulati (1995b) also showed that social network (past alliances) facilitates

new alliance formation by providing valuable information to firms about their specific capabilities and reliability of potential partners. Walker et al. (1997) further demonstrated in a sample of biotechnology firms that network structure indicates both where social capital is distributed in the industry and where opportunities for entrepreneurial actions are located and thus determines the frequency with which a new firm establishes new relationships. Shan et al. (1994) and Stuart (1998) showed that firms in crowded technological positions and those with high prestige form alliances at the highest rates. This is because the structural position of the firm creates – and therefore also limits – its abilities to implement cooperative strategies successfully (Shan et al., 1994). Firms in crowded technological positions have similar technology base and thus they have good potential to exploit each other, while technological prestige enhances the opportunities to find partners and make favourable contracts with them (Stuart, 1998).

Ahuja (2000) examined the impact of direct ties, indirect ties and structural holes in firm's network of alliances on its innovation output. Based on a sample of 97 leading firms from the chemicals sector Ahuja (2000) showed that both direct and indirect network relationships have positive impact on the firm's number of patents. As indirect ties entail relatively low or no maintenance costs for the firm, Ahuja (2000) emphasized that indirect ties enhance network effectiveness. Structural holes may also lead to negative consequences on innovative output, as they increase the firm's exposure to potential malfeasance, although they also enlarge the diversity of information that the firm has access to (Ahuja, 2000). Katila and Ahuja (2002) further showed firms search efforts vary across two dimensions: search depth or how frequently the firm re-uses its existing knowledge, and search scope or how widely the firm explores new knowledge. Katila and Ahuja (2002) found that the interaction between search depth and search scope is positively related to innovation performance measured as the number of new products.

Another essential research topic in the alliance network structure literature has been to examine how the characteristics of inter-organizational ties influence learning and innovation performance. This research has commonly distinguished two complementary

dimensions of network ties: 1) diversity or heterogeneity, and 2) affective or emotional strength (Aldrich, 1999). The diversity refers to persons of differing social locations and characteristics, whereas strength refers to the duration of relationship, the frequency of contact and the extent of trust (Aldrich, 1999). Granovetter (1973) in his seminal work already indicated that weak ties, i.e. distant and infrequent, are beneficial for the search for new knowledge as they are more likely to provide novel and non-redundant knowledge than strong ties. Kogut and Zander (1992) emphasized strong ties, i.e. close and frequent, to be more advantageous than weak ties in transferring new knowledge, especially when the knowledge is tacit and complex. The strong and weak ties have thus different benefits, which has been referred to as the search-transfer problem in prior research (Hansen, 1999). Tiwana (2008) demonstrated that while bridging ties that span structural holes are associated with high innovation potential, strong ties are needed to realize the innovation potential.

Table 3 provides an overview of prior empirical research on the impact of inter-organizational relationships on innovation and learning performance. It demonstrates that alliances and partnerships have in general been shown to have a positive impact on innovation and learning measured as patent counts (Ahuja, 2000; Becker and Dietz, 2003; de Man and Duysters, 2005; Hagedoorn and Duysters, 2002; Shan et al., 1994). Especially, related alliances have been demonstrated to improve learning (Lane and Lubatkin, 1998) and patenting rates (Keil et al., 2003) due to the existence of absorptive capacity. Moreover, firms that form alliances with large and innovative partners perform better in terms of patenting rates and sales growth than otherwise comparable firms that lack such partners (Stuart, 2000). The access to heterogeneous knowledge and complementary and strategically important resources also enhances learning and innovation performance (Baum et al., 2000; Lunnan and Haugland, 2008; Schildt et al., 2005; Rodan and Galunic, 2004). In regard to the sources of innovation, prior studies have shown that relationships with R&D institutions and public institutions especially enhance firm's patenting output (Miotti and Sachwald, 2003; Rominj and Albaladejo, 2002).

Table 3. Overview of prior studies on the impact of inter-organizational relationships on innovation and learning

Study	Type of relationship	Performance measure	Empirical data	Main findings
Hagedoorn and Shakenraad (1994)	<ul style="list-style-type: none"> ▪ Strategic technology alliance 	<ul style="list-style-type: none"> ▪ Patent intensity ▪ Economic performance 	<ul style="list-style-type: none"> ▪ 346 large firms from the U.S., Japan and Europe in information technologies and electronics, mechanical engineering and process industries 	<ul style="list-style-type: none"> ▪ Patent intensive corporations are heavily involved in strategic partnering.
Shan et al. (1994)	<ul style="list-style-type: none"> ▪ Number of start-up agreements with commercial firms until 1989 	<ul style="list-style-type: none"> ▪ Number of patents issued to a start-up firm until 1989 	<ul style="list-style-type: none"> ▪ 114 start-up firms in the biotechnology industry until 1989 	<ul style="list-style-type: none"> ▪ Cooperative agreements of start-up firms have a positive effect on the rate of patenting.
Deeds and Hill (1996)	<ul style="list-style-type: none"> ▪ Strategic alliances 	<ul style="list-style-type: none"> ▪ Rate of product development 	<ul style="list-style-type: none"> ▪ All 132 biotechnology firms in the U.S. developing therapeutics or diagnostics as of 1991 	<ul style="list-style-type: none"> ▪ There is an inverted U-shaped relationship between the number of strategic alliances and the rate of new product development.
Lane and Lubatkin (1998)	<ul style="list-style-type: none"> ▪ Alliances 	<ul style="list-style-type: none"> ▪ Inter-organizational learning (based on expert assessment) 	<ul style="list-style-type: none"> ▪ 69 alliances from 1985 to 1993 (22 biotechnology and 48 pharmaceutical firms) 	<ul style="list-style-type: none"> ▪ Firm's ability to learn in alliance relation is dependent on the similarity of firms' knowledge bases, organizational structures, compensation policies and dominant logics.
Ahuja (2000)	<ul style="list-style-type: none"> ▪ Alliances 	<ul style="list-style-type: none"> ▪ Number of patents 	<ul style="list-style-type: none"> ▪ 97 leading firms from the chemicals industry in W. Europe, Japan and the U.S 	<ul style="list-style-type: none"> ▪ Both direct and indirect alliance relationships enhance patenting output.
Baum et al. (2000)	<ul style="list-style-type: none"> ▪ Alliances 	<ul style="list-style-type: none"> ▪ R&D spending growth ▪ R&D employee growth 	<ul style="list-style-type: none"> ▪ 142 start-ups and 471 incumbent biotechnology firms 	<ul style="list-style-type: none"> ▪ The variation in alliance networks that start-ups configure influences their early performance.
Stuart (2000)	<ul style="list-style-type: none"> ▪ Alliances 	<ul style="list-style-type: none"> ▪ Number of patents ▪ Sales growth 	<ul style="list-style-type: none"> ▪ 150 semiconductor firms during the period from 1985 to 1991 	<ul style="list-style-type: none"> ▪ Technology alliances with large and innovative partners enhance innovation and growth rates.
Rosenkopf and Nerkar (2001)	<ul style="list-style-type: none"> ▪ Formal, contractual, inter-organizational agreements 	<ul style="list-style-type: none"> ▪ Patent classes 	<ul style="list-style-type: none"> ▪ 22 firms in the U.S. optical disk industry and their 2333 patents granted between 1971 and 1995 	<ul style="list-style-type: none"> ▪ Exploration that spans organizational boundaries has a higher impact on technological evolution than exploration that does not span organizational boundaries.

Study	Type of relationship	Performance measure	Empirical data	Main findings
Hagedoorn and Duysters (2002)	<ul style="list-style-type: none"> ▪ Strategic technology alliance 	<ul style="list-style-type: none"> ▪ Patent intensity, i.e. the number of patents divided by revenues 	<ul style="list-style-type: none"> ▪ 88 companies operating in the international computer industry 	<ul style="list-style-type: none"> ▪ In a dynamic environment, there is a positive relationship between learning-based alliances and technological performance.
Rominj and Albaladejo (2002)	<ul style="list-style-type: none"> ▪ Customers, suppliers, competitors, financial institutions, training institutions, R&D institutions, service providers and industry associations 	<ul style="list-style-type: none"> ▪ Number of patents 	<ul style="list-style-type: none"> ▪ 33 small software-development and electronics manufacturing companies in the U.K 	<ul style="list-style-type: none"> ▪ The interaction with R&D institutions and service providers increases the innovation capability of firms.
Becker and Dietz (2003)	<ul style="list-style-type: none"> ▪ Joint R&D relations with other firms and institutions ▪ Cooperation partners 	<ul style="list-style-type: none"> ▪ Realization of product innovations 	<ul style="list-style-type: none"> ▪ 2048 firms in German manufacturing industry 	<ul style="list-style-type: none"> ▪ Joint R&D enhances innovation output. ▪ The number of cooperation partners is positively related to innovation output.
Keil et al. (2003)	<ul style="list-style-type: none"> ▪ Related partnership 	<ul style="list-style-type: none"> ▪ Number of patents 	<ul style="list-style-type: none"> ▪ 67 companies in the U.S. information and communication technology industry 	<ul style="list-style-type: none"> ▪ Related partnerships increase the rate of patenting.
Miotti and Sachwald (2003)	<ul style="list-style-type: none"> ▪ Cooperation with customers, suppliers, competitors, institutions and universities. 	<ul style="list-style-type: none"> ▪ Patenting ▪ Share of innovative products in turnover 	<ul style="list-style-type: none"> ▪ 4215 French manufacturing firms with more than 10 employees 	<ul style="list-style-type: none"> ▪ Cooperation with public institutions enhances patenting, while vertical cooperation increases the share of innovative products in turnover.
Rodan and Galunic (2004)	<ul style="list-style-type: none"> ▪ Employee contacts that help them to be creative and support the generation of new ideas (self-assessment) 	<ul style="list-style-type: none"> ▪ Employee creativity and the ability to implement novel ideas (managerial assessment) 	<ul style="list-style-type: none"> ▪ 106 middle managers in a European telecommunication company 	<ul style="list-style-type: none"> ▪ Access to heterogeneous knowledge has greater impact on innovation performance than network structure.
de Man and Duysters (2005)	<ul style="list-style-type: none"> ▪ Review of alliance literature 	<ul style="list-style-type: none"> ▪ Number of patents ▪ R&D investments ▪ Product and process innovation ▪ R&D productivity and licenses 	<ul style="list-style-type: none"> ▪ Approx. 10 papers on the impact of alliances on innovation performance 	<ul style="list-style-type: none"> ▪ The impact of collaboration on innovation is highest: 1) when firms have strong alliance management capability and 2) the partners have overlapping or similar knowledge bases.

Study	Type of relationship	Performance measure	Empirical data	Main findings
Schildt et al. (2005)	<ul style="list-style-type: none"> ▪ Corporate venture capital ▪ Alliance ▪ Joint venture ▪ Acquisition 	<ul style="list-style-type: none"> ▪ Patent citations to partners' patents and own patents (exploitative learning) ▪ Patent citations only to partners' patents (explorative learning) 	<ul style="list-style-type: none"> ▪ 110 largest U.S. public corporations in four sectors of ICT industries: computer equipment, electronics, software and telecommunications 	<ul style="list-style-type: none"> ▪ Non-equity venturing alliances are more suitable for explorative learning than joint ventures or acquisitions. ▪ Technological relatedness and downstream vertical relatedness decrease the likelihood of explorative learning.
Smith et al. (2005)	<ul style="list-style-type: none"> ▪ Direct contacts that employees have and their strength ▪ Organizational climate 	<ul style="list-style-type: none"> ▪ Number of new products 	<ul style="list-style-type: none"> ▪ 73 technology firms 	<ul style="list-style-type: none"> ▪ New product and service introduction is a function of organizational members' ability to combine and exchange knowledge.
Subramaniam and Youndt (2005)	<ul style="list-style-type: none"> ▪ External and internal collaborations 	<ul style="list-style-type: none"> ▪ Incremental innovation capability ▪ Radical innovation capability 	<ul style="list-style-type: none"> ▪ 93 U.S. public organizations with more than 100 employees in multiple industries 	<ul style="list-style-type: none"> ▪ Social capital influences positively both incremental and radical innovative capabilities.
Sampson (2007)	<ul style="list-style-type: none"> ▪ R&D alliances 	<ul style="list-style-type: none"> ▪ Patents (after alliance has been created) 	<ul style="list-style-type: none"> ▪ 463 R&D alliances in the telecommunications equipment industry 	<ul style="list-style-type: none"> ▪ Alliances contribute more to firms' innovation when technological diversity (the extent which partners patent in the same technology classes) is moderate, rather than low or high.
Lunnan and Haugland (2008)	<ul style="list-style-type: none"> ▪ Contractual alliances 	<ul style="list-style-type: none"> ▪ Abrupt termination ▪ Short-term performance ▪ Long-term performance 	<ul style="list-style-type: none"> ▪ 100 alliances formed by member companies of the Federation of Norwegian Engineering Industries 	<ul style="list-style-type: none"> ▪ Alliances considered strategically important are less likely to be abruptly terminated. ▪ Access to complementary and strategically important resources affects short-term performance. ▪ Specific investments in human capital combined with the ability to develop and expand alliance activities over time influence long-term performance.

Table 3 also demonstrates that prior studies have focused on examining formal inter-organizational relationships such as contractual alliances and partnerships. This is despite that there is a wide array of informal collaborations and interactions between members of individual firms (Powell et al., 1996). The reason for the lack of studies on informal inter-organizational relationships is due to the difficulty to identify and thus study these relationships (Hagedoorn et al., 2000). Table 3 shows that patent counts have been commonly used as a measure of innovation performance and patent citations as a measure of both knowledge flows and subsequent learning outcomes. Some of the more recent studies, Lunnan and Haugland (2008), Rodan and Galunic (2004) and Subramaniam and Youndt (2005) have adopted qualitative measures of innovation performance based on managerial assessments in order to provide more fine-grained analysis on the impact of inter-organizational relationships on innovation. Most of prior studies have used organizations as the unit of analysis, except Rodan and Galunic (2004) that examined individual managerial performance in a sample of 106 middle managers in a European telecommunication company.

Limitations of prior research and suggested areas of future research

The emergence of microfoundations approach encourages studying the dynamics of knowledge creation from the perspective of individual interactions, which has been rare in prior studies on the resource-based view, the knowledge-based view and the social capital (Barney, 2001; Felin and Foss, 2006; Langley, 2007). The microfoundations approach enables studying informal inter-organizational relationships, which is little studied in prior research (Hagedoorn et al., 2000; Simard and West, 2006). This is despite that many authors have urged future research to study informal inter-organizational relationship (Gulati, 1995a; Powell et al., 1996; Simon and West, 2006). The main goal of the microfoundations approach is to bring potentially new information to existing organization-level explanations on knowledge creation (Argote and Ingram, 2000; Felin and Foss, 2006).

There are few in-depth studies that would describe how inter-organizational relationships increase innovativeness in the development of patents. As extant literature on patents is largely based on information present in patent documents, it has not been able to sufficiently study collaboration in invention processes (Giuri et al., 2007). Joint patenting is the only measure that in the patent document provides information on inter-organizational collaboration in the patent development. Given the numerous studies on the positive impact of alliances on a firm's patenting rate, it would be natural to assume that the wide use of alliances would lead to joint patenting by the partnering companies. However, in the study of Hagedoorn et al. (2003), no evidence was found that alliances would lead to joint patenting by partnering companies. This paper compared jointly-owned U.S. patents filed in 1989-1998 with the MERIT-CATI database of R&D alliances. Moreover, Giuri et al. (2007) recently demonstrated that joint patenting is a rare phenomenon, as in their study of 9017 European patents the share of co-applied patents was only 3.6%. This is despite more than 20% of these patents being developed in inter-firm collaboration. Thus, it is unclear based on current literature how inventors utilize external collaborations in the development of patents. Hagedoorn (2003) and Giuri et al. (2007) only conclude that as property rights in co-owned patents remain partial, it is likely that firms try to avoid joint patenting, also in patents developed in collaboration (Giuri et al., 2007; Hagedoorn, 2003). Powell et al. (1996) claimed that alliance relationships may be utilized indirectly to other purpose than the original aim of partnership. This would explain why there are so little joint patents between partners. Current literature offers though little explanation on how inter-organizational relationships are utilized in the development of patents due to the lack of in-depth studies.

Katila and Ahuja (2002) suggest future research to use complementary methods such as surveys and case studies to measure how organizations search new and existing knowledge and how this contributes to performance. There have so far been few surveys or interviews with inventors to understand better the nature of invention processes (Giuri et al., 2007). Meyer (2000) and Tijssen (2002) examined the role of scientific knowledge in technology development based on interviews and surveys with the inventors. Meyer (2000) studied how patent citations actually relate to inventions

through a case study of 10 nanotechnology patents. The interviews with the inventors behind patents were chosen as the only possible method to clarify this issue (Meyer, 2000). As key findings, Meyer (2000) reveals that citation linkages hardly represent the origin of the invention, although he confirms that scientific activities provide an important background for the inventors in technological development. Moreover, Tijssen (2002) demonstrated based on a mail survey amongst Dutch inventors that patent citations referring to basic research literature are invalid indicators of a technology's science dependence. One reason for this is that there are many patent documents lacking such citations, which cannot be considered less science-dependent than patent documents including these citations (Tijssen, 2002).

Giuri et al.'s (2007) recent survey of inventors of 9017 patents from six large European countries is an important step in clarifying the current understanding in regard to the extent of collaboration and the sources of external knowledge in the patent development. Giuri et al. (2007) found customers and users to be the most important sources of external knowledge, followed by knowledge supplied by patent literature and scientific literature in invention processes. Other sources of external knowledge used in the development of patents were competitors, technical conferences and workshops, suppliers, universities and public research laboratories (Giuri et al., 2007). Giuri et al.'s (2007) paper represents one of few studies that have examined patent development from the perspective of inventors. It is closely related to the topic of publications I and II in the thesis. However, being a large survey it was unable to clarify how inventors actually acquired and utilized external knowledge in the patent development process.

2.2.2 Alliance developmental processes and the dynamics of cooperation

Success factors in alliances and partnerships

Earlier research has emphasized that the existence of inter-organizational ties is not enough to create successful cooperation. Parkhe (1993) demonstrated through a transaction cost and game theory perspective that successful inter-firm cooperation rests on two basic building blocks: 1) initiation of a mutually beneficial relationships and 2) fading of the fear of opportunism. Based on survey data from 111 senior executives on alliances developed in 1983-1988, Parkhe (1993) found that high behavioral transparency between partners, long time horizons, and frequent interactions help to build superior alliance performance and fade the fear of opportunism.

The resource-based view, knowledge-based view and social capital literature have emphasized trust, motivation and combination capability to contribute to successful knowledge exchange and combination between partners (Galunic and Rodan; 1998; Kogut and Zander, 1992; Nahapiet and Ghoshal, 1998). For instance, similar organizational structures, compensation policies and dominant logics enhance partners' capability to absorb knowledge from each other (Lane and Lubatkin, 1998). Moreover, prior interaction between partners, high learning stakes and long-term orientation empower the collective learning process (Larsson et al., 1998). For long-term performance of alliances, specific investments in human capital and the ability to develop and expand alliance activities over time are critical (Anand and Khanna, 2000; Heimeriks and Duysters, 2007; Lunnan and Haugland, 2008). Larsson et al. (1998) argue that the management of collective learning process in an inter-firm relationship plays a central role in determining the success and failure of an alliance.

Prior studies have demonstrated that tension in inter-organizational relationships may arise because of the conflicting pressures of simultaneous competition and cooperation (Das and Teng, 2000; Khanna et al., 1998). If the private benefits of partners are higher than the common benefits, their incentives to invest in learning diminish

(Khanna et al., 1998). Moreover, strategic alliances need to balance between rigid and flexible structures as well as between short-term and long-term orientation (Das and Teng, 2000). The dominance of one is not likely to lead to sustainable strategic alliances (Das and Teng, 2000). Tidd et al. (2005) emphasized that problems associated with collaborative projects are often related to the management of relationships between partners. Table 4 summarizes success factors of collaborative R&D projects (Tidd et al., 2005).

Table 4. Factors contributing to the success of collaborative R&D (Tidd et al., 2005)

<ul style="list-style-type: none"> • The collaboration is perceived as important by all partners • The existence of a collaboration ‘champion’ • A substantial degree of trust exists between the partners • Clear project planning and defined task milestones are established • Frequent communication between partners, in particular between marketing and technical staff • The collaborating parties contribute as expected • Benefits are perceived to be equally distributed

Alliance evolution and the dynamics of cooperation

Although prior literature has shown that the management of collaborative projects is challenging, the current literature on alliance evolution is limited to a small number of conceptual models of inter-organizational processes as well as case-based studies (Reuer et al., 2002). Alliance implementation has received far less attention than firms’ initial investment decisions concerning alliances in management literature. This is despite the management of alliance dynamics ultimately determines alliance success or failure (Ariño et al., 2008; Doz, 1996; Hamel, 1991; Tidd et al., 2005).

The literature on alliance evolution and the dynamics of cooperation is based on pioneering work of Doz (1996) and Ring and Van de Ven (1994). Ring and Van de Ven (1994) determined inter-organizational cooperative agreements to evolve in a cyclical process that contains periods of negotiation, commitment and execution each of which

is assessed in terms of its efficiency and equity outcomes. Doz (1996) argued that alliance projects can only be successful if partnering firms are able to continuously learn, re-evaluate and readjust the initial alliance conditions. Ariño and de la Torre (1998) integrated the process frameworks of Ring and Van de Ven (1994) and Doz (1996). They utilized this process framework in a case study of an international joint venture from its creation to dissolution. Ariño and de la Torre (1998) found how external changes, either in the environment or in the strategic context in which the alliance develops, triggered partners to re-assess the alliance conditions. The authors showed how partners engaged in a renegotiation of the terms of the contract, or modified their behavior unilaterally, in an attempt to restore balance to the relationship. Ariño and de la Torre (1998) concluded trust and goodwill to contribute to successful renegotiation of alliance conditions and showed that unsuccessful renegotiation gradually leads to the deterioration of a partnership relationship, which causes the joint venture dissolution.

Koza and Levin (1998), Kumar and Nti (1998) and White (2005) contributed with additional frameworks of alliance evolution. Koza and Levin (1998) emphasized the need to study alliances in the context of adaptation choices of the firm over time. The authors suggested that strategic alliances are embedded with the firm's history and strategic portfolio that co-evolve with the firm's strategy, the institutional, organizational, and competitive environment, and with management strategic intent for the alliance. Kumar and Nti (1998) described how collaborative strategies adopted by the partners and the managerial mechanism governing the alliance influence each other and constitute a pattern of interaction among the partners, which leads to either the creation of favourable or unfavourable process discrepancies. The absorptive capacities of partners and the pattern of interaction jointly determine alliance outcomes, which combined with expected outcomes create either favourable or unfavourable outcome discrepancies (Kumar and Nti, 1998). Kumar and Nti (1998) conclude that alliance outcome together with changes in the environment and the grand strategies of the partners determine the evolutionary path of alliances. White (2005) developed a framework of alliance cooperation costs, governance choice and alliance evolution,

which emphasized that both the costs and the benefits of cooperation determine alliance evolutionary path.

In addition to generic models of alliance evolution, there are several survey-based studies that have tested governance and contract changes in alliances. For example, Reuer et al. (2002) investigated based on a survey of 81 biotech and pharmaceutical firms the antecedents of alliance ex post governance changes - significant contractual alterations, major changes in the joint board or committee overseeing the alliance, or the introduction or formalization of monitoring mechanisms. Reuer et al. (2002) found that ex post governance changes tend to occur more frequently when parent firms have engaged in prior alliances together and the collaboration is highly relevant to the parent firm based on its resource commitments to the collaboration, whilst post-governance adjustments occur less often when the firm has prior experience with collaborative projects on similar subjects and when partners establish a clear division of labor for the alliance. Moreover, Ariño et al. (2008) investigated based on a survey of 91 Spanish firms whether there are differences between small and large firms in adjusting alliances' contracts. Ariño et al. (2008) concluded that small firms are no more or less likely to adjust their alliances' contracts, but they tend to bear two kinds of inefficiencies in their collaborations. First, they are less likely to adapt alliances in the presence of governance misalignments. Second, small firms are more prone to make transaction-specific investments, which can stimulate ex post hold-up in the form of contractual renegotiations.

Prior literature also features case studies on the development of alliance capability (e.g. Heimeriks et al., 2007) and social capital in organizations (e.g. Maurer and Ebers, 2006). These studies have supported managerial practice in the management of inter-organizational relationships. For instance, Maurer and Ebers (2006) found based on a comparative case study of new German biotechnology firms that horizontal and vertical differentiation in organizing the management of external relations and the integration of the information and resources that are provided by external partners are important factors to overcome inertia in the development of social capital.

There have been little case studies in regard to the management of alliance project evolution, i.e. addressing the managerial challenges in implementing alliance projects. This is despite that prior literature has highlighted that the management of alliance evolution is important determinant of its success. Brouthers and Bamossy's (2006) study is similar to the publication III of the thesis, as it utilizes a comparative case methodology and focuses on understanding managerial challenges in the context of projects. Brouthers and Bamossy (2006) identify barriers to international joint ventures success and the post-formation processes used to overcome these barriers, based on eight international joint ventures between Western multinational enterprises and Eastern European state owned enterprises. As a result, the authors propose that intensive training programs in language and business skills as well as personnel exchanges and training at parent headquarters reduce cultural differences and develop trust between international joint venture partners. Moreover, Brouthers and Bamossy (2006) indicate that open communications and cooperative problem solving styles and the dominance of local managers develop inter-firm trust, which in turn leads to higher international joint venture performance perceptions. These findings support managers in implementing international joint ventures. The publication III examines other types of managerial challenges, as it focuses on collaborations with customers in the context of R&D projects.

The topic of coping with project dynamics e.g. unpredictable events and setbacks that occur during ongoing R&D collaborations have been little explored so far in prior literature. This is despite that there is a vast body of literature on change management that considers how to carry and lead large change initiatives within organizations. The project management literature has not yet adequately covered the management of project uncertainty (Ward and Chapman; 2003). There are a few change management models developed for project management e.g. Voropajev (1998) model for transition economies and Al-Sedairy (2001) model for Saudi construction industry, which do not though cover the context of inter-organizational projects. Voropajev (1998) and Al-Sedairy (2001) studies are close to the topic of publication IV, which builds on them in the development of the generic change management model for inter-firm project change

management. Table 5 provides an overview of earlier papers on alliance evolution and the dynamics of cooperation.

Table 5. Overview of prior studies on alliance evolution and the dynamics of cooperation

Study	Research method	Type of relationship	Empirical data	Main findings
Hamel (1991)	<ul style="list-style-type: none"> ▪ Case study, theory development 	<ul style="list-style-type: none"> ▪ Alliances 	<ul style="list-style-type: none"> ▪ Nine international alliances 	<ul style="list-style-type: none"> ▪ Intent, receptivity and transparency as determinants of inter-partner learning. ▪ Process may be more important than structure in determining learning outcomes in alliances.
Ring and Van de Ven (1994)	<ul style="list-style-type: none"> ▪ Conceptual paper, results based on the integration of prior work 	<ul style="list-style-type: none"> ▪ Cooperative inter-organizational relationships 	<ul style="list-style-type: none"> ▪ None 	<ul style="list-style-type: none"> ▪ A process framework that illustrates the development of cooperative inter-organizational relationships in repetitive cycles of negotiations, commitments and executions. ▪ A set of propositions that explain how and why cooperative IORs emerge, evolve, and dissolve.
Doz (1996)	<ul style="list-style-type: none"> ▪ Case study, theory development 	<ul style="list-style-type: none"> ▪ Strategic alliances 	<ul style="list-style-type: none"> ▪ Two cases of new business and new product development 	<ul style="list-style-type: none"> ▪ A process framework of alliance evolution in repetitive cycles of learning, re-evaluation and readjustment.
Ariño and de la Torre (1998)	<ul style="list-style-type: none"> ▪ Case study, theory extending 	<ul style="list-style-type: none"> ▪ International joint venture 	<ul style="list-style-type: none"> ▪ Longitudinal data from the creation of an international joint venture to its dissolution in the consumer products industry 	<ul style="list-style-type: none"> ▪ When major external change occurs that influences equity conditions of one partner, trust and goodwill are essential enablers of successful renegotiation of alliance conditions between partners. In the absence of trust and goodwill, partners will have difficulty to resolve the situation, which may lead to the dissolution of the partnership.
Koza and Levin (1998)	<ul style="list-style-type: none"> ▪ Conceptual paper, results based on the integration of prior work 	<ul style="list-style-type: none"> ▪ Strategic alliances 	<ul style="list-style-type: none"> ▪ None 	<ul style="list-style-type: none"> ▪ A co-evolutionary framework of strategic alliances, which views alliances to be embedded in a firm's strategic portfolio and to co-evolve with the firm's strategy. This view emphasizes the need to study alliances in the context of adaptation choices of the firm over time.
Kumar and Nti (1998)	<ul style="list-style-type: none"> ▪ Conceptual paper based on the integration of prior work and descriptive case examples 	<ul style="list-style-type: none"> ▪ Alliances 	<ul style="list-style-type: none"> ▪ None 	<ul style="list-style-type: none"> ▪ A framework of alliance evolution, which views alliance partners to assess alliance conditions based on its process and outcome discrepancies, which together with changes in the environment and the grand strategies of the partners determine alliance evolutionary path.

Study	Research method	Type of relationship	Empirical data	Main findings
Larsson et al. (1998)	<ul style="list-style-type: none"> ▪ Conceptual paper, results based on the integration of prior work 	<ul style="list-style-type: none"> ▪ Strategic alliances 	<ul style="list-style-type: none"> ▪ None 	<ul style="list-style-type: none"> ▪ Typology of learning strategies in alliances.
Reuer et al. (2002)	<ul style="list-style-type: none"> ▪ Survey study, theory testing 	<ul style="list-style-type: none"> ▪ Alliances 	<ul style="list-style-type: none"> ▪ 81 biotech and pharmaceutical firms that cover 145 collaborative alliances 	<ul style="list-style-type: none"> ▪ Antecedents of ex post governance changes in strategic alliances
White (2005)	<ul style="list-style-type: none"> ▪ Conceptual paper based on the integration of prior work and a descriptive case study 	<ul style="list-style-type: none"> ▪ Alliances 	<ul style="list-style-type: none"> ▪ The NedCar alliance between Mitsubishi Motors Corporation and Volvo in the Netherlands 	<ul style="list-style-type: none"> ▪ A framework of alliance cooperation costs, governance choice and alliance evolution that captures a range of factors that are sources of alliance inefficiency. It provides dimensions for distinguishing among different types of alliances, sources of alliance failure, and managerial means of structuring alliances ex ante and adapting to changes as alliances evolve after formation.
Brouthers and Bamossy (2006)	<ul style="list-style-type: none"> ▪ A comparative case study 	<ul style="list-style-type: none"> ▪ Joint ventures 	<ul style="list-style-type: none"> ▪ Eight international joint ventures between Western multinational enterprises and Eastern European state owned enterprises 	<ul style="list-style-type: none"> ▪ The identification of barriers to international joint venture success and the post-formation processes used to overcome these barriers e.g. intensive training programs in language and business skills, open communication and cooperative problem-solving styles.
Maurer and Ebers (2006)	<ul style="list-style-type: none"> ▪ A comparative case study 	<ul style="list-style-type: none"> ▪ Firms' external contacts 	<ul style="list-style-type: none"> ▪ Six German successful and less successful biotechnology start-up firms 	<ul style="list-style-type: none"> ▪ The identification of how social capital enhances start-up performances. The study suggests that cohesive external network ties are needed in the start-up phase. In the business development phase, the management of old ties and the development of new cohesive ties with other constituencies together influence firm performance.
Ariño et al. (2008)	<ul style="list-style-type: none"> ▪ A survey, theory testing 	<ul style="list-style-type: none"> ▪ Alliances 	<ul style="list-style-type: none"> ▪ 91 Spanish firms in 1986-1992 	<ul style="list-style-type: none"> ▪ The examination of whether there are differences between small and large firms in adjusting alliance contracts. As result, no differences are found in the likelihood to adjust contracts, but small firms tend to bear two kinds of inefficiencies to adjust contract terms.

Limitations of prior research and suggested areas of future research

Hennart (2006) emphasizes that studying alliances in general faces two main challenges. First, the term alliance covers a wide variety of economic institutions, from simple supply contracts to equity joint ventures and to everything else in between (licensing, franchising, distribution agreements, lending contracts, etc). This is why alliances may involve many different types of management challenges depending on its form. Second, alliances are bound to complexity as for instance alliance performance depends on multiple factors such as 1) chance events which can affect the parents and the alliance, (2) unpredictable economic changes in the environment, (3) mistakes by managers of the parents and of the alliance, (4) the attention and resources the alliance receives from its parents and (5) the structure of the alliance. Due to the complexity more detailed analyses of organizational processes are needed to improve the current understanding on how day-to-day activities in organizations relate to strategic outcomes (Johnson et al., 2003). Moving the attention from macro level of organizations to micro-level dynamics has been proposed as essential to the theory development (Felin and Foss, 2006; Johnson et al., 2003). Doz (1996) argued that process research is valuable as it can combine different levels of analysis, individual and inter-personal with project, organizational and strategic contexts.

There are several limitations in prior studies that have examined the alliance evolution and the dynamics of cooperation. The main limitation is the theoretical diversity and thus insufficient knowledge accumulation (Bell et al., 2006). As prior studies on the dynamics of cooperation have utilized a variety of theoretical perspectives to explain the same phenomena, the research findings are difficult or even impossible to compare, which results in an academic gap (Bell et al., 2006). For example, Ariño and de la Torre (1998), Reuer et al. (2002) and Ring and Van de Ven (1994) emphasize transaction cost perspective, while Doz (1996) and Heimeriks et al. (2007) the resource-based view and Maurer and Ebers (2006) the social capital perspective. Future research should align assumptions and find core concepts that integrate prior studies (Bell et al., 2006). Applied research designs should be in line

with the nature of the proposed theory in order to produce valid and reliable findings (Bell et al., 2006). Moreover, studying particular events and actions that can contribute more generally such as activities that commonly underpin and explain competitive advantage should be used to increase the generalizability of studies (Johnson et al., 2003; Langley, 2007).

The literature on the dynamics of cooperation has been claimed to have addressed questions that are irrelevant to managers' need, which have resulted a managerial relevance gap (Bell et al., 2006). Many studies on the dynamics of cooperation have resulted in generic theoretical frameworks that give little guidance on what managers should actually do to improve the chances for alliance success (Bell et al., 2006). Some studies have tracked change events in the evolution of alliances, but failed in suggesting how managers should act when changes occur during inter-firm projects. In order to contribute to managerial gap, future research should focus on research topics that are connected to managerial concerns e.g. how to revitalize underperforming alliances (Bell et al., 2006).

As the topic of alliance dynamics remains relatively uncharted territory, it presents many new avenues for inquiry in organizational studies and entrepreneurship such as the implication of post-formation changes on alliance longevity, success and performance outcomes (Ariño et al., 2008). In studying the implications of social capital, future research could devote more attention to studying with whom actors connect, and to which resources they can thereby potentially gain access, rather than examining only how actors connect (Maurer and Ebers, 2006). In addition, there is a need for future studies to provide a deeper understanding of how to handle the complexity of developmental processes in inter-organizational partnerships (Lunnan and Haugland, 2008).

3 Summary of individual publications

This chapter presents an overview of the individual publications in regard to their theoretical background, key objectives, research approach and key findings. Each publication is presented in its own section. At the end of the chapter Table 6 summarizes the publications in terms of research questions, underlying theories, main empirical domains, research methods and key findings.

3.1 The role of inter-organizational relationships in the development of patents: A knowledge-based approach

This publication, whose theoretical roots are mainly in the knowledge-based view, aims at making two contributions. First, it is intended to provide increased understanding of dynamics in external knowledge acquisition and utilization in the context of patent development through adopting the microfoundations approach. Second, the publication is intended to contribute to the knowledge-based view through improving the link between individual-level interaction in knowledge creation and firm-level patent competitiveness.

The publication is based on a case-study approach, which is a typical method when the focus is a knowledge-based view (Hoskisson et al., 1999). The case company selected is a large Finnish telecommunication services provider that has a reputation for being an innovative company. Data triangulation was used in order to produce a rich understanding of the role of inter-organizational relationships in the invention process and in competitiveness with respect to patents. Several expert interviews were carried with the case company R&D managers and patent engineers. Face-to-face interviews followed with 13 inventors who were responsible for 72 company patents. A survey was then conducted in order to evaluate statistically the influence of inter-organizational relationships on patent competitiveness. A total of 28 inventors responded to the survey, which covered 90 patent development processes between 1996 and 2004 and

represented 43% of the total of 209 case company patents developed in that period. The survey results were analyzed through systematic comparison of patent development processes and statistical evaluation of the impact of different types of inter-organizational relationships on patent competitiveness.

In terms of key findings, this publication reveals the importance of informal interaction with suppliers and customers and participation in R&D consortia. This interaction helps inventors generate new ideas and solve problems related to patents. These types of inter-organizational relationships are typically invisible in large-scale studies at the organization level, as they cannot be easily tracked via surveys or alliance databases. The definition of inter-organizational relationships used in this paper is broader than in previous patent surveys that have examined inter-organizational relationships only as patents developed in collaborations (Giuri et al., 2007; Rominj and Albaladejo, 2002).

This publication also reveals that inventors combine the acquired external knowledge with their own internal knowledge, which is in line with KBV literature on knowledge creation processes (Kogut and Zander, 1992; Nonaka and Takeuchi, 1995; Zollo and Winter, 2002). The resulting new knowledge combinations were not transferred outside the company before the patent application was filed. Knowledge appropriability has been an issue in the development of technology-enabled services, in which the protection provided by legal mechanisms is weak and imitation is rather easy.

The publication also demonstrates that customer and supplier relationships are more valuable to an operator than R&D consortia relationships in terms of patent competitiveness, as they are likely to reduce the market and technology uncertainty related to the exploitation of patents. As the definition of competitiveness is based on the firm's present resources, it appears more difficult for an operator to exploit patents based on R&D consortia than supplier and customer knowledge, as these patents aim for more long-term and radical innovations.

3.2 Search-transfer behaviour, knowledge heterogeneity and organizational learning

The theoretical background of the publication II lies in the knowledge-based view, organizational learning theory and social capital. This publication contributes to extant literature through increasing understanding of the process of external learning in the context of patent development. It tests five hypotheses concerning the impact of external and internal knowledge search and internal knowledge transfer on learning inside the firm. A case-study approach was adopted, which was supported by the collection of process data on patent development. The case company is a large Finnish telecommunication operator. A survey was conducted in order to evaluate statistically the influence of inter-organizational relationships on learning. The survey covered 90 patent development processes in the case company between 1996 and 2004. In addition, ten semi-structured interviews were used to describe the process of learning in the development of patents. The results were analyzed qualitatively as well as quantitatively using the ordinal logistic regression method.

This publication demonstrates how inventors' interactions with external contacts involving heterogeneous knowledge enhance individual learning, and provides examples of the underlying process. It also shows that whilst external ties enhance individual learning, internal knowledge transfer is needed to increase organizational learning. Based on the in-depth analyses of four patent development processes, this publication indicates that both opportunistic and problem-driven searches may initiate the learning process. Organizational learning is found to be more likely to occur in the case of problem-driven search, as it typically entails an improvement to current organizational routines rather than a radical change. While the recent literature in the knowledge-based view has called for a problem-solving perspective to analyze how knowledge and capability can be generated in organizations (Nickerson and Zenger, 2004), publication II suggests that we need also to understand how organizations can foster opportunistic search and overcome the barriers related to implementation in order to enable the renewal of organizational resources and capabilities.

3.3 Knowledge creation and exploitation in collaborative R&D projects: Lessons learned from success factors

The theoretical background of publication III lies in the knowledge-based view and social capital. Whilst prior research has identified the conditions for successful inter-firm collaboration, this publication examines key factors supporting the successful implementation of these conditions in collaborative R&D projects with customers. This is intended to contribute to current literature and managerial practice.

This publication is based on a case study of five collaborative R&D projects within a case company in the telecommunication services sector. These case projects entail both successful and unsuccessful projects in order to obtain a fruitful research setting for cross-project comparisons. The primary research data were collected through in-depth interviews with six project participants in April-June 2004 and through direct observations in project meetings of one collaborative case project in April-June 2002. The secondary data were obtained in the form of project documents and presentations. Research data were utilized to compare the key events and actions that contributed to, or challenged, the process of knowledge creation and exploitation in the five collaborative R&D projects examined in the research.

In terms of key findings, this publication highlights several managerial actions that support the implementation of collaborative R&D projects with customers. The creation of genuine 'win-win' situations, clear roles and responsibilities, the customer-oriented approach and facilitation of direct interaction with specialists with complementary knowledge bases all contributed positively to the inter-firm process of knowledge creation. Assessment of the viability of the business opportunity was found to be the primary managerial action that is needed to ensure successful knowledge exploitation. While some of these managerial actions have been identified in prior literature as well, this publication contributes specifically with a better understanding of how they are linked to the enabling conditions of successful inter-organizational knowledge creation defined in prior research. For managerial practice, publication III provides support on how to implement successful R&D collaborations with customers.

3.4 Coping with project dynamics in an inter-firm project context

Publication IV aims at providing new insights and guidance with respect to the management of change in collaborative R&D projects. Despite the vast literature on alliances there has been little research on the subject of actually coping with project dynamics during an ongoing inter-firm project. Even the project management literature has not covered the management of project uncertainty (Ward and Chapman, 2003). The theoretical background of this paper lies in the resource-based view of the firm.

This publication is based on a case study of two inter-firm R&D projects. The primary data on project change management were gathered through 15 individual interviews in February-June 2001 and two business process group simulation sessions with project participants from both partnering companies in May 2001. The secondary data were gathered from project documents that featured project descriptions, meeting minutes, process charts and prior interview notes. Data were analyzed through systematic comparison of change management activities in two case projects.

This publication develops a generic change management process based on prior literature and indicates how the generic process needs to be adapted due to different environmental and change-specific aspects. The characteristics of the environment, such as industry, firm, project and inter-firm cooperation, were found to set the detailed requirements in regard to, for instance, the hierarchy and method of decision-making and the extent of joint change management between the partners. The characteristics of change, depending on the source, range and significance, were found to influence the nature of change analyses and the decision-making body required. Publication IV contributes to the resource-based view with new insight into the management of change in collaborative R&D projects. Its findings are also relevant for project management literature and managerial practice.

Table 6. Summary of individual publications

	Publication I	Publication II	Publication III	Publication IV
Research questions	<ul style="list-style-type: none"> ▪ How do inventors acquire and utilize external knowledge in the process of patent development? ▪ How does the inventors' external interaction contribute to patent competitiveness? 	<ul style="list-style-type: none"> ▪ How do the inventors acquire and utilize external knowledge in the process of patent development? ▪ How does the inventors' external interaction contribute to learning? 	<ul style="list-style-type: none"> ▪ Which managerial actions contribute to successful knowledge creation and exploitation in collaborative R&D projects? 	<ul style="list-style-type: none"> ▪ How should managers cope with project dynamics in the context of inter-firm R&D projects?
Underlying theories	<ul style="list-style-type: none"> ▪ Resource-based view of the firm ▪ Knowledge-based view 	<ul style="list-style-type: none"> ▪ Knowledge-based view, organizational learning theory ▪ Social capital perspective 	<ul style="list-style-type: none"> ▪ Knowledge-based view ▪ Social capital perspective 	<ul style="list-style-type: none"> ▪ Resource-based view of the firm
Main empirical domains	<ul style="list-style-type: none"> ▪ Inter-organizational relationships ▪ Patent development/invention process 	<ul style="list-style-type: none"> ▪ Inter-organizational relationships ▪ Patent development/invention process 	<ul style="list-style-type: none"> ▪ Inter-organizational relationships ▪ Innovation process ▪ R&D project management 	<ul style="list-style-type: none"> ▪ Inter-organizational relationships ▪ Innovation process ▪ R&D project management
Research methods and data collection	<ul style="list-style-type: none"> ▪ Case study approach ▪ Interviews and a survey with inventors behind case company patents 	<ul style="list-style-type: none"> ▪ Case study approach ▪ Interviews and a survey with inventors behind case company patents 	<ul style="list-style-type: none"> ▪ Case study approach ▪ Interviews with project participants 	<ul style="list-style-type: none"> ▪ Case study approach ▪ Interviews with project participants and business process simulation sessions
Key findings	<ul style="list-style-type: none"> ▪ New insights on the role and nature of inter-organizational relationships in the development of patents ▪ The importance of informal inter-organizational relationships ▪ The improved link between individual interaction and patent competitiveness 	<ul style="list-style-type: none"> ▪ New insights on the mechanism of knowledge creation in the context of patenting ▪ The improved link between the individual interaction and learning 	<ul style="list-style-type: none"> ▪ Managerial actions that support implementing the conditions of successful collaboration in inter-firm R&D projects 	<ul style="list-style-type: none"> ▪ The development of a generic change management process model for inter-firm R&D projects ▪ The identification of the impact of environmental and change-specific factors on generic change management process

4 Key contributions of the thesis

This chapter discusses the key contributions of the thesis to extant literature. It focuses on showing how this thesis brings new insights to the strategic management literature through the microfoundations approach. While inter-organizational relationships in the invention and innovation processes have been studied extensively, there are a limited number of studies about underlying process dynamics from the perspective of individual action and interactions. This chapter highlights the findings in the thesis that partly complement and partly challenge prior literature. The chapter closes with the explication of the relevance of the thesis to managerial practice.

4.1 Contributions to literature

There have recently been calls for the microfoundations approach to increase the understanding of the role of individual action and interactions in influencing organizational value creation and capture (Argote and Ingram, 2000; Felin and Foss, 2005; Johnson et al., 2003; Nickerson et al., 2007; Teece, 2007). Furthermore, strategic management research has been urged to adopt process thinking, which involves considering phenomena dynamically – in terms of movement, activity, events, change and temporal evolution (Langley, 2007). This thesis contributes to the resource-based view, knowledge-based view and social capital through studying inter-organizational relationships in invention and innovation processes using the microfoundations approach. This is intended to bring new insights into current literature in regard to how individual actions and interactions enhance knowledge creation and exploitation and how they lead to firm-level outcomes. The detailed contributions of the thesis are presented in the following sections.

4.1.1 The role and nature of inter-organizational relationships in the development of patents

Both the knowledge-based view and social capital perspective have emphasized inter-organizational relationships to facilitate knowledge exchange and combination, thus laying the ground for organizational competitiveness (Kogut and Zander, 1992; Maurer and Ebers, 2006; Nahapiet and Ghoshal, 1998; Nonaka and Takeuchi, 1995). This thesis takes a dynamic view of the phenomena by studying it through the microfoundations approach, while prior research has focused on the organizational level. The thesis examines how inter-organizational relationships are actually utilized in different phases of the patent development process from the perspective of inventors in publications I and II. It indicates that the role of inter-organizational relationships in the patent development process is mainly external knowledge acquisition in both the idea generation and the problem-solving phase. The acquired external knowledge is combined with internal knowledge inside the firm for new knowledge creation. On a general level, this finding is in line with earlier studies on organizational knowledge creation processes (Kogut and Zander, 1992; Nonaka and Takeuchi, 1995; Zollo and Winter, 2002).

This thesis found the nature of inter-organizational ties to be informal and infrequent in the patent development process. According to the inventors behind the patents this is due to appropriation concerns. Prior studies have demonstrated that firms prefer to use formal governance structures when appropriation concerns are high (Gulati and Singh, 1998). In contrast, the present thesis indicates that informal inter-organizational relationships such as close working relations with suppliers and customers may also be seen as a relevant strategy by the firm to enhance innovativeness without entering into more formal partnerships. As property rights in co-owned patents remain partial (Giuri et al., 2007; Hagedoorn, 2003), the use of informal relationships in the development of patents enables firms to avoid possible conflicts of ownerships rights and still benefit from external knowledge. Although formal governance structures typically involve tighter collaboration than informal structures, this thesis found that informal inter-organizational relationships are valuable sources of new ideas and support problem-

solving in the context of patenting. It demonstrates that in the case of patent development, the existing inter-organizational relationships that a firm has, contribute to its development of patents, although these relationships are not specifically designed for joint development of inventions. This finding provides support for the Powell et al. (1996) claim that inter-organizational relationships may also contribute indirectly.

4.1.2 The importance of informal inter-organizational relationships

In terms of a key contribution, this thesis reveals the importance of informal inter-organizational relationships in publications I and II. Prior research into strategic management has focused on examining formal inter-organizational relationships such as contractual alliances and partnerships. The reason for this is that formal ties are easily recognized at the level of organizations, while informal ties are only to be recognized at the level of individuals (Simard and West, 2006).

Whilst earlier literature has emphasized the importance of weak ties for individual creativity (Granovetter, 1973; Perry-Smith, 2006) and customers and suppliers as important sources of innovation (Giuri et al., 2007; Teece, 2007, Tushman, 1977; Utterback, 1971; von Hippel, 1988), the contribution of this thesis lies essentially in describing how informal relationships with customers, suppliers and R&D consortia are actually utilized in different phases of the invention process. While prior research on patents is largely based on information present in patent documents, it has not yet covered collaboration sufficiently in this context (Giuri et al., 2007). This thesis demonstrates how inventors' participation in external events such as standardization meetings, future-oriented vendor or supplier presentations and customer collaborations is essential for generating the stimulus for new service ideas or detecting knowledge gaps in existing products or technology. Informal inter-organizational relationships also provide an important channel for inventors to acquire detailed knowledge about customer needs and customers' technical environment, vendor/supplier products and the state of existing technologies in standards. This knowledge supports inventors in finding

a functioning technical solution that is aligned with customer needs and requirements. Although prior studies have demonstrated inter-organizational relationships for enhancing innovativeness (e.g., Ahuja, 2000; Dutta and Weiss, 1997; Shan et al., 1994; Stuart, 2000), the thesis contributes with a more in-depth description of the underlying process.

4.1.3 The impact of individual-level interaction in the patent development process on patent competitiveness and learning

This thesis integrates process and content issues through the microfoundations approach, while strategic management research has traditionally provided separate tracks for process and content studies (Johnson et al., 2003; Nerur et al., 2008). The thesis examines knowledge flows and content in the patent development process based on interviews and a survey with the inventors behind patents. It relates the inventors' interactions in the development of patents to firm-level outcomes. The microfoundations approach adopted in publications I and II improves causal understanding in regard to the relationship between individual level interactions and patent competitiveness and learning within the firm.

As a key contribution, this thesis takes an important step in measuring innovation performance through qualitative outcome measures; in contrast, prior studies have typically used patent counts (Simard and West, 2006; Spender and Grant, 1996; Hagedoorn and Cloudt, 2003). It measures patent competitiveness based on the inventors' assessment on patent value, rareness, non-imitability and compatibility with current organizational resources to exploit it. Publication I indicates that supplier and customer relationships enhance patent competitiveness more than R&D consortia relationships. The benefit of the supplier and customer relationship lies in their ability to reduce market and technology uncertainty with respect to the patented solution. However, as the definition for patent competitiveness is the firm's present resources, this measure values short-term innovations over long-term innovations. It is important,

therefore, to note that R&D consortia often aim for more radical and long-term innovations.

Publication II of the thesis examines link between inventors' search-transfer behaviour in the development of patents and learning outcomes. It measures individual and organizational learning through a survey directed at the inventors behind patents. Prior research has criticized earlier studies in organizational learning regarding them as having failed to incorporate multiple levels of organizational learning (Aldrich, 1999; Inkpen and Crossan, 1995). Publication II indicates that the inventors' external interactions in searching for new knowledge significantly contribute to individual learning, while internal interactions do not have the same effect. It also demonstrates that multi-functional knowledge transfer in the commercialization of the patent contributes to organizational learning. Thus, publication II essentially demonstrates that both external and internal learning are needed for successful innovation development.

In sum, the results of publications I and II are in line with prior studies on the knowledge-based view, social capital and open innovation literature in emphasizing the contribution of inter-organizational relationships for learning and innovation. In addition to extant literature, the thesis moreover proposes that the value of patents and the ability of a firm to exploit them are influenced by with whom the inventor interacts in the development of patents.

4.1.4 Managerial actions for successful implementation of collaborative R&D projects

The knowledge-based view and the social capital perspective provide a number of key conditions for facilitating knowledge exchange and combination for organizational advantage such as trust, motivation and similar organizational structures and dominant logics (e.g. Grant, 1996a; Lane and Lubatkin; 1998; Nahapiet and Ghoshal, 1996). The thesis in publication III contributes to this literature through identifying managerial actions that support the implementation of these conditions in collaborative R&D

projects with customers. Prior literature has argued that while vast attention has been given in the identification of initial conditions of successful alliance projects, little attention has been paid to the actual implementation of these factors in collaborative projects (Ariño et al., 2008; Doz, 1996; Gerwin, 2004; Gulati, 1998, Trott, 2002). This is despite that actual processes seldom go as predicted. Prior studies have indeed demonstrated that a large proportion of inter-firm collaborations fail to achieve their goals regardless of the great potential that they entail (Doz, 1996; Gulati, 1998; Khanna et al., 1998).

Publication III examines managerial actions and key events in the evolution of five collaborative R&D projects that led to the creation of favourable or unfavourable conditions during the project. In terms of key findings, it identifies managerial actions such as the creation of clear roles and responsibilities, facilitation of direct interaction between specialists, communication to all project stakeholders and customer-oriented education and training to support successful inter-firm knowledge creation. Publication III reveals these factors to be more important for project success than the existence of old relationships between the collaborating firms. While prior studies on the macro level have demonstrated that previously allied firms are likely to engage in further alliances (Gulati, 1995b) and that alliance experience enhances alliance performance (Heimeriks and Duysters, 2007), this thesis shows that project management needs always to be deeply engaged in the project. It cannot rely on old successes in the hope that they will be automatically repeated. As people change during the life of a project, it is important for project management to monitor and support continuously the relationships between the project participants so they develop favourably. This example demonstrates the necessity of managers to pay attention to people issues and actions to sustain favourable progress in collaborative projects.

The assessment of the viability of the business opportunity to both partners prior to project start was found to enhance the motivation of the partners and also to lay the necessary ground for successful knowledge exploitation. In fact, the greatest disappointment for project participants in one case project occurred when the technical solution developed was excellent, but it was never implemented as the related financial

returns were estimated to be too low. The project manager had succeeded in motivating the project participants and creating an innovative atmosphere, but failed in analyzing the underlying business potential at the beginning of the project. This is why the invention developed was never commercialized. Indeed, the viability of the business opportunity was found to be the primary factor contributing to successful knowledge exploitation in publication III.

This thesis supports theory development in regard to the successful implementation of collaborative R&D projects with customers. The major contribution lies in linking conditions of successful inter-organizational knowledge creation from earlier literature on the knowledge-based view and social capital with managerial actions that support their implementation. For instance, the creation of clear roles and responsibilities and joint project management practices was found to increase the motivation of project participants in inter-firm R&D projects. Moreover, the detailed definition of customer requirements early in the project as well as thorough project documentation and the joint review of it were found to enhance the ability to integrate knowledge between partners. The thesis has described the related project events from the project manager's perspective and so provides a foundation for further research into successful and unsuccessful episodes of collaborative knowledge creation.

4.1.5 The development of generic change management process for inter-firm R&D projects

Publication IV of the thesis contributes to the resource-based view in regard to coping with project dynamics in collaborative R&D projects. Prior research has emphasized the importance of alliance partners to continuously learn and adjust the initial project conditions, which are influenced by external changes (Ariño and de la Torre, 1998; Doz, 1996; Ring and Van de Ven, 1994). The emerging literature on alliance dynamics has though offered so far little guidance that would support managers facing problems in partnership evolution (Bell et al., 2006). Publication IV develops a

change management process model for inter-firm projects that supports project managers in identifying and implementing necessary change during an ongoing project. Based on a case study, it identifies managerial actions which are needed to respond to change situations in order to avoid negative consequences for project parameters (i.e. scope, quality, time, cost and resources). These data are collected from project participants through interviews and business process group simulation sessions.

Publication IV demonstrates how environmental and change-specific factors influence the implementation of the generic change management process. This type of approach is helpful in extending the applicability of the specific case study results in other situations (Johnson et al., 2003). For instance, publication IV clarifies how firm characteristics such as size, structure and value chain position have an influence on the number of stakeholders and the hierarchy and method of decision-making in change management process. Moreover, it shows how the characteristics of inter-firm collaboration, such as the distribution of decision rights and the extent of joint activities, determine the power structure in decision-making and the extent of joint change management required. Change-specific factors, such as the significance of change, are found to determine the extent of change analyses required as well as the decision-making body.

Prior literature has emphasized change management as one of the key challenges in the context of collaborative projects (Pelín, 1996); yet, there have been few studies addressing this topic. Even the project management literature has not adequately covered the topic of project uncertainty (Ward and Chapman, 2003). Current project management guidelines pose a restricted view of change, as they focus only on the project risk management process (Duncan, 1996; Ward and Chapman, 2003). The generic change management process developed in publication IV supports project managers in identifying positive change signals and diminishing the impact of negative changes on the project. It suggests that the existing concept of risk management in project management literature should be replaced with the concept of change management. This is needed in order to highlight that change may also have positive implications on projects and assist project managers in coping with project dynamics.

4.2 Managerial implications

The innovation management literature shows that the most critical task of R&D management is to ensure effective knowledge integration and learning (Tidd et al., 2005). This thesis provides practical support for R&D managers in successful utilization of inter-organizational relationships for knowledge creation and exploitation. Publications I and II highlight the importance of R&D consortia, supplier and customer interactions in the development of patents. The knowledge that resides in these external contacts supports the generation of innovative ideas and lowers market and technology uncertainty related to the commercialization of inventions. Due to high appropriation concerns with non-patented knowledge, these informal relationships can also be seen as part of a firm's strategy for enhancing its innovativeness without entering into more formal partnerships that might later result in conflicts over ownership rights.

Publications I and II also highlight the importance of proper innovation performance measures and rewards. This is essential for R&D managers in order for them to be able to encourage employees to create both incremental and radical innovations. Although radical innovations are typically more difficult to implement than incremental innovations and also value capture takes longer, organizations need to invest in them as they are important for organizational renewal. Publications I and II show that the inventors behind patents need to be rewarded for patent applications as well as successful patents and also for the support they give for other organizational members in exploiting patents. This is essential as the inventors are the only ones in the organization who deeply understand the details of the patents and thus are essential for driving and assisting in the change required for the implementation of the patents.

Prior research on the dynamics of collaboration has been claimed to provide little managerial relevance (Bell et al., 2006). The topics of publication III and IV have been developed based on managerial concerns on how to contribute to positive development of R&D collaborations. Both publication III and publication IV give guidance to

managers in regard to how to initiate R&D collaborations and how to cope with the dynamics that arise in the evolution of R&D collaborations. Publication III provides lessons learned for R&D managers with respect to success factors in implementing collaborative R&D projects with customers. Based on cross-case comparison of successful and unsuccessful collaborative R&D projects, this research presents a number of issues that a project manager should check before starting an inter-firm project; these include, e.g. the existence of clear customer need, viability of business case for both partners, and a well-defined project scope. This research also suggests key factors for a project manager in motivating project participants such as the definition of clear goals and responsibilities for all participants as well as ensuring direct inter-firm links between specialists who have complementary knowledge-bases. Moreover, it demonstrates how managerial actions for structuring project meetings, keeping coherent project documentation and facilitating customer-oriented communication and guidance support favourable project progress.

Publication IV develops a change management process for inter-firm R&D projects and assists in its implementation. This is especially valuable for managers of collaborative projects in order to prepare for external and internal changes that may occur during the project. The incorporation of a change management process supports project managers in managing sudden changes and then taking advantage of them, whilst having regard to minimizing project delay and additional cost. Based on a common plan and change management process, both partners know how to act when change occurs. Publication IV also demonstrates that in complicated technical matters, it is vital that project managers establish a cross-project group to support change analysis from various perspectives and to recommend appropriate actions to be taken.

5 Limitations

Case studies are commonly used to enhance understanding of causal relationships and the accuracy of measurement, but as a trade-off they are typically associated with decreased generalization of results. In order to improve the generalization of results, the accumulation of knowledge in this thesis was supported by using a comparative case method across all publications. The generalization was enhanced in publication IV through the development of a change management process framework capable of extension to account for environmental and change-specific factors.

Although this thesis strived to enhance the generalization of the results, they cannot yet be fully generalized to other contexts. The case studies in the research are based on analyses of a large Finnish telecommunication operator or among R&D collaborations between companies in the Finnish telecommunications sector during the period 1996 to 2004. It may be that the results of this research will not hold for small and medium-sized firms, other countries or for more stable, low technology environments. The study of inter-organizational relationships in the patenting context was based solely on the case of a telecommunications operator. Prior research has demonstrated that the role of patents is minor in the services sector compared to manufacturing, although among services sectors the role of patents is highest within telecommunications (Hipp and Grupp, 2005). It may be that the results of that specific study are not applicable to companies in other sectors.

Another limitation, partly inherent to the theoretical approaches used in this thesis, is the difficulty of measuring key concepts such as patent competitiveness. Publications I and II utilized self-reported data from the inventors of patents, which is subjective in nature. Prior research has commonly used easily quantified data such as patent counts and patent citations as a proxy of innovation performance. However, the latter measures cannot reveal the firm's success in translating patents and products into competitive advantage, which is why qualitative self-reported data were utilized in this thesis. It was not possible in the present study to obtain the assessment of managers on patent competitiveness. The managers did not have detailed enough knowledge of specific

patents and thus referred to the inventors whom they felt knew best the potential underlying specific patents. Giuri et al. (2007) tested how the responses of patent inventors in evaluating patent value differed with those of company managers in a sample of French patents. They found that whilst patent inventors slightly overestimated the value of their patents, their responses were equally distributed.

Publication II has also limitations in the measurement of dependent variables. Both individual and organizational learning have been measured with a single item, whilst the use of a multiple items scale would have been better given the complexity of the learning process. The current measure of organizational learning captured essentially whether or not inventors were able to transfer knowledge to other organizational members in the implementation phase (of their inventions), not to evaluate the full learning effect at the organizational level.

Publications III and IV can only provide guidance in regard to the management of collaborative R&D projects and cannot guarantee high innovation performance. This is due to the unpredictable nature of innovation processes. It is important to bear in mind that no single tool or process practices can guarantee innovation success (Tidd et al., 1997).

6 Conclusions and future studies

This thesis has brought new insights into extant literature in regard to the role and nature of inter-organizational relationships in the development of patents through the microfoundations approach. It linked the findings of individual-level interaction to firm-level performance in terms of patent competitiveness and learning. The results are significant for strategic management research in demonstrating the importance of informal inter-organizational relationships and describing how individual actions contribute to firm-level competitive advantage.

In addition, this thesis has provided in-depth studies on the management of collaborative R&D projects. These studies describe managerial actions that influence successful knowledge creation and exploitation as well as coping with challenges that arise from project dynamics. These results extend strategic management literature in regard to the successful implementation of collaborative R&D projects.

As this thesis was based on the case study approach, the overall suggestion for future research is to test the applicability of the results to multiple companies, industries and countries. Publications I and II point to future studies which should incorporate the microfoundations approach and utilize a broader definition of inter-organizational relationships in order to understand better the role of diverse external contacts and interactions for innovation. It would be valuable to examine whether or not formal inter-organizational relationships are in other cases utilized in the development of patents and how firms in these situations solve the issues related to appropriation concerns. This type of micro level study is required to clarify why despite increased partnership activity there are still few joint patents between companies. As appropriation concerns play a central role in determining the extent to which firms collaborate in the development of patents, the present study highlights the need to analyze further the implications on collaborative innovation processes. Moreover, future studies are needed to improve the accuracy of measuring patent competitiveness and learning outcomes related to patent development.

In regard to the management of collaborative R&D projects, it would be valuable to test the generic change management process presented in publication IV in other firms and industries. If the change management process was found to have wide applicability, this would suggest that it could replace the current concept of risk management in project management guidelines. Further case studies are needed to address other areas of inter-firm project management. These studies would contribute to the resource-based approaches in regard to the implementation of collaborative projects. They would moreover support project management literature to develop comprehensive guidelines for the management of inter-organizational projects and thus to support project managers of inter-organizational projects.

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