

MATTI MAJURI

# Interfirm Collaboration in R&D Projects

Effects of Social Capital on Knowledge Transfer



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ACADEMIC DISSERTATION

To be presented, with the permission of  
the Faculty of Engineering and Natural Sciences  
of Tampere University,  
for public discussion in the auditorium Pieni Sali 1  
of the Festia building, Korkeakoulunkatu 8, Tampere,  
on 23 June 2022, at 12 o'clock.

ACADEMIC DISSERTATION

Tampere University, Faculty of Engineering and Natural Sciences  
Finland

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Cover design: Roihu Inc.

ISBN 978-952-03-2472-8 (print)  
ISBN 978-952-03-2473-5 (pdf)  
ISSN 2489-9860 (print)  
ISSN 2490-0028 (pdf)  
<http://urn.fi/URN:ISBN:978-952-03-2473-5>

PunaMusta Oy – Yliopistopaino  
Joensuu 2022

# ACKNOWLEDGEMENTS

I would like to express my deep gratitude to Professor Minna Lanz and Professor Pauli Kuosmanen, my dissertation supervisors, for their guidance of the research work reported in this dissertation. Your wise advice and encouragement enabled me to conclude my doctoral journey. Thank you, Professor emeritus Reijo Tuokko. For a decade I was fortunate to have you as my close mentor.

I wish to thank various people for their contribution to my academic efforts; kind and wise Dr. Stephen Fox for the altruistic assistance you gave me during the long writing process of the fifth paper and preparing the dissertation; Dr. Eeva Järvenpää for her patience as my campus “roommate” and being always ready to give me a helping hand when needed; Dr. Jaani Väisänen for giving me advice when I familiarized myself with the qualitative comparative analysis; and Dr. Nillo Adlin for the fruitful collaboration in our shared research efforts.

I also want to thank the “originals” Roni-Jussi Halme, Julius Pesonen and Toni Perälä. You were the ones with whom I had a great pleasure to start my academic career with. In addition, I would like to offer my special thanks to my current team leader Harri Länsipuro for the flexibility that enabled me to finish the dissertation.

I wish to thank my parents, Heikki and Seija, and sister Riikka for their support and encouragement throughout my study.

And finally, I want to thank the three bright stars of my life, my fine sons Heikki and Eino, and my dear wife Heidi. Eventually, it was your light that guided me through also this process.



# ABSTRACT

Through various forms of collaboration, firms are seeking to support their research and development (R&D) activities. Simultaneously, governments are encouraging firms and universities/research institutes to collaborate by offering funding for R&D projects. Previous research has given insights into interfirm R&D collaboration, for example, in supply chains and strategic alliances. Also, in the context of R&D projects, the collaboration between firms and universities has been the focus of several studies. However, a research gap exists concerning interfirm collaboration in R&D project networks. This research gap is addressed in this dissertation, which consists of an introductory section and five scientific papers.

The research presented in the dissertation progressed in a funnel-like process. During the first phases of the study, the aim was to build an overall picture of interfirm R&D collaboration. For this purpose, expert workshops were held, and the literature was reviewed. The results are reported in papers 1 and 2 of the dissertation. In later phases, the study focused on the identification of factors that hinder or facilitate interfirm knowledge transfer (KT) in the context of R&D projects. The effects of structural, relational and cognitive social capital on KT were studied in detail. A qualitative case study approach was taken. Data were gathered by interviewing firm representatives from seven R&D projects that had received funding from a Finnish public funding agency. The results are reported in papers 3, 4 and 5.

The dissertation builds a picture of the diversity of the potential factors that affect interfirm R&D collaboration in project networks. The findings indicate that social capital does facilitate KT in R&D project networks, but it needs to be accompanied by shared business intentions (motivation) to obtain the most beneficial outcomes. In addition, several factors were identified that can limit the facilitative influence of motivation and social capital.



# TIIVISTELMÄ

Monet yritykset tekevät tutkimus- ja kehittämissyhteistyötä muiden yritysten ja tutkimusorganisaatioiden sekä yliopistojen kanssa edistääkseen omia kehittämistavoitteitaan. Yhteistyötä tuetaan julkisin varoin moninaisilla projektirahoituksen instrumenteilla, joissa edellytetään usein, että hankekonsortion jäsenenä on useampia yrityksiä. Aikaisempi tutkimus on ansiokkaasti lisännyt ymmärrystä erilaisiin yhteistyömalleihin, kuten toimitusverkostoihin ja strategisiin kumppanuuksiin, liittyvästä dynamiikasta. Lisäksi on tutkittu aktiivisesti yritysten ja yliopistojen välistä yhteistyötä julkista rahoitusta saavissa tutkimus- ja kehittämishankkeissa. Kuitenkin yritysten väliseen yhteistyöhön tutkimus- ja kehittämissyhteistyön kontekstissa keskittynyttä tutkimusta on erittäin vähän. Tämä väitöskirja paikkaa kyseistä tutkimusvajetta. Väitöskirja koostuu johdanto-osasta sekä viidestä tieteellisestä artikkelista.

Väitöskirjassa raportoitava tutkimus eteni suppilomaisesti. Tutkimuksen alkuvaiheessa tavoitteena oli rakentaa kokonaiskuvaa yritysten välisestä tutkimus- ja kehittämissyhteistyötä, ja sen tuloksellisuuteen potentiaalisesti vaikuttavista tekijöistä. Tätä tarkoitusta varten pidettiin asiantuntijatyöpajoja ja tehtiin kirjallisuuskartoituksia. Näistä saadut tulokset raportoitiin väitöskirjan artikkeleissa yksi ja kaksi. Myöhemmissä vaiheissa tutkimus keskittyi tarkastelemaan yritysten välistä tiedonsiirtoa vauhdittavia tai hidastavia tekijöitä julkista tukea saavissa tutkimus- ja kehittämissyhteistyöprojekteissa. Erityisenä painopisteenä oli selvittää rakenteellisen, relationaalisen ja kognitiivisen sosiaalisen pääoman vaikutuksia yritysten väliseen tiedonsiirtoon. Tutkimusmenetelmänä käytettiin kvalitatiivista tapaustutkimusta, jossa aineisto kerättiin haastatteleamalla yritysedustajia seitsemästä tutkimus- ja kehittämissyhteistyöprojektista. Tutkimustulokset on raportoitu artikkeleissa kolme, neljä ja viisi.

Väitöskirjassa esiteltävä tutkimus tuo esiin monipuolisesti tekijöitä, jotka potentiaalisesti vaikuttavat yritysten välisen tutkimus- ja kehittämissyhteistyön sujuvuuteen. Tulokset osoittavat, että sosiaalinen pääoma vauhdittaa yritysten välistä tiedonsiirtoa, mutta sen fasilitoiva vaikutus tehostuu selvästi, kun yrityksillä on yhteisiä liiketoiminnallisia tavoitteita (motivaatio). Toisaalta tutkimuksessa

tunnistettiin useita tekijöitä, joiden läsnäolo heikentää sosiaalisen pääoman ja motivaation fasilitoivaa vaikutusta.

# CONTENTS

1	Introduction.....	17
1.1	Background.....	17
1.2	Knowledge gap and research questions .....	19
1.3	Structure of the dissertation .....	21
2	Theoretical framework.....	23
2.1	A brief review of R&D collaboration research in the management literature .....	23
2.2	A brief review on knowledge-related research in the management literature .....	26
2.3	Enablers and barriers of interorganisational KT.....	29
2.3.1	Absorptive capacity.....	30
2.3.2	Stickiness.....	30
2.3.3	Distances.....	31
2.3.4	Embeddedness.....	33
2.4	Social capital.....	33
2.4.1	Structural social capital.....	36
2.4.2	Relational social capital.....	37
2.4.3	Cognitive social capital.....	39
2.5	Summary of theoretical framework.....	40
3	Methodology.....	42
3.1	Research design.....	42
3.2	Real-life context, data collection and analysis.....	43
3.3	Validity.....	45
4	Results.....	48
4.1	Capabilities of interfirm R&D collaboration .....	48
4.2	Uniqueness of firms' R&D project networks.....	50
4.3	Limitations of interfirm collaboration in R&D projects.....	51
4.4	Social capital effects on interfirm knowledge transfer in R&D project networks.....	53
4.4.1	Significance of structural social capital to knowledge transfer.....	54
4.4.2	Significance of relational social capital to knowledge transfer.....	54

4.4.3	Significance of cognitive social capital to knowledge transfer.....	55
5	Discussion.....	57
5.1	Theoretical contributions .....	57
5.2	Implications for R&D project management and innovation policies.....	61
5.3	Limitations and recommendation for future research .....	63
6	Conclusions .....	65

*List of Figures*

<b>Figure 1</b>	The big picture of the research
<b>Figure 2</b>	Research questions, methods and findings
<b>Figure 3</b>	Factors influencing interorganisational knowledge transfer
<b>Figure 4</b>	Social capital dimensions, facets, and features
<b>Figure 5</b>	Summary of the research aspects
<b>Figure 6</b>	Funnel-like progress of the research
<b>Figure 7</b>	Real-life context of the research, phases 2 and 3
<b>Figure 8</b>	Significance of various capabilities in different phases of the collaborative innovation process
<b>Figure 9</b>	Quality and quantity of collaboration, firms/informants 1–8

*List of Tables*

<b>Table 1</b>	Aspects and examples of research on R&D collaboration
<b>Table 2</b>	Summary of the research methods
<b>Table 3</b>	Social capital characteristics in R&D project networks and strategic alliances
<b>Table 4</b>	Reasons limiting the collaboration in cases 1–7

**Table 5** Perceived benefits from interfirm knowledge transfer, and knowledge transfer platforms



# ABBREVIATIONS

DC	Dynamic capabilities
EU	European Union
KT	Knowledge transfer
OL	Organisational learning
R&D	Research and development
SME	Small and medium-sized enterprise



# ORIGINAL PUBLICATIONS

- Publication I Majuri, M., Halme, R-J., Kopra, M-J., Nylund, H., 2015. Collaborative Innovation Capabilities of SME Network. In: Chike F. Oduoza (eds). Proceedings of the 25th International Conference on Flexible Automation and Intelligent Manufacturing: designing for advanced, high value manufacturing and intelligent systems for the 21st century, FAIM 2015, 2(175), 404-409.
- Publication II Majuri, M., Halonen, N., 2019. Capability Building Through Dynamic Capabilities and Organizational Learning. In: Leal Filho W., Azul A., Brandli L., Özuyar P., Parede T. (eds). Responsible Consumption and Production, Encyclopedia of the UN Sustainable Development Goals, 49-59.
- Publication III Majuri, M., Lanz, M., 2018. Social Capital Characteristics in R&D Project Networks. In: Proceedings of PICMET '18: Technology Management for Interconnected World, 1-5.
- Publication IV Majuri, M., Nylund, H., Lanz, M., 2016. Analysis of Inter-firm Co-operation in Joint Research and Development Projects. In: Nääs I. et al. (eds). Advances in Production Management Systems. Initiatives for a Sustainable World. APMS 2016. IFIP Advances in Information and Communication Technology, 488, 536-543.
- Publication V Majuri, M., 2022. Inter-firm knowledge transfer in R&D project networks: A Multiple Case Study. Technovation 115.



# 1 INTRODUCTION

## 1.1 Background

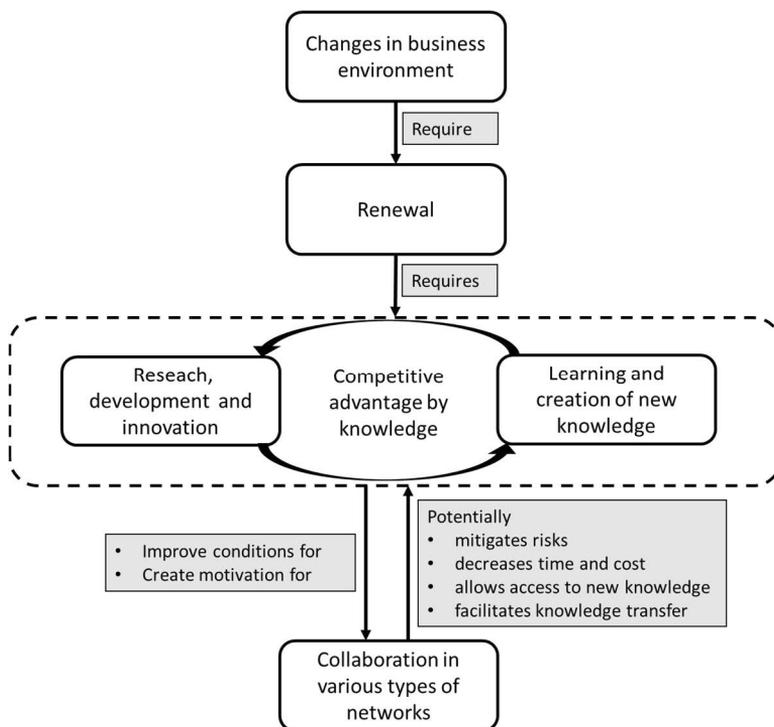
Ever since the first businesses were established, change has been a constant companion of business life. However, in modern days, change itself has changed. Changes are faster, bigger, and harder to predict than ever before (Koulopoulos, 2006). Additionally, in the global economy, everything can affect everything else, meaning that more potential sources of change exist compared with simply local or national economies. Unfortunately, during the time of writing this introduction section of the dissertation, an example of this kind of change—COVID-19—is causing damage to global supply chains, not to mention the lives of people in general. Sometimes, the suddenness or unpredictability of the change is a result of a rapid increase of awareness, not so much because of the nature of the change force itself, for example, global warming, which has continued for decades but has influenced global business mainly during the last decade. The natural response from firms to compete successfully in ever-changing markets is renewal. This is not just the case offerings-wise, but also the renewal of capabilities is required (Jovane, 2009).

To renew offerings and capabilities, firms seek for new solutions through research and development (R&D) activities. The creation of new knowledge and learning are required for effective R&D, and on the other hand, the creation of new knowledge and learning are stimulated by R&D activities. If successful, the previous leads to a knowledge-based competitive advantage (Grant, 1996; Drucker, 1988; Spender and Grant, 1996).

Collaboration creates an opportunity for a firm to enhance the processes of knowledge creation and R&D and to explore new knowledge. Collaboration can reduce R&D costs (e.g., Littler et al., 1995), facilitate knowledge creation (e.g., Lawson et al., 2009), allow access to external knowledge, allow from benefitting from resources without ownership (Lavie, 2006), complement competencies (e.g., Hagedoorn 1993) and mitigate risks (e.g., Eisenhardt and Schoonhoven, 1996). On the other hand, strong R&D capabilities and a solid knowledge base make firms more desirable partners for collaboration, thus opening better opportunities for

collaboration. Additionally, the motivation for collaboration may increase as firms recognise learning and knowledge gaps as they conduct their own R&D activities.

A notable perspective for collaboration is looking at who is collaborating. From the value chain’s perspective, collaboration can be horizontal or vertical (Belderbos et al., 2004). Horizontal collaboration would be between, for example, brand owners from different value chains or suppliers from the same tier in the same value chain. Vertical collaboration exists, for example, when suppliers and their customers collaborate. In addition, institutional collaboration (Belderbos et al., 2004) exists when nonfirm actors collaborate together or with firms. However, a single taxonomy of network types has yet to be developed. In addition, it is unclear on what basis the classification should be made of. Despite this somewhat challenging situation, research should pay special attention to defining the characteristics of the studied network because the collaboration may take significantly different forms depending on the type of the network (e.g., role of formal governance in supply chains versus industrial districts). The previous paragraphs are summarised in **Figure 1**.



**Figure 1.** The big picture of the research.

Currently, collaborative R&D and project-based collaboration are encouraged by several public national or international funding instruments and programmes (Rajalo and Vadi, 2017), for example, Horizon 2020 in EU and Co-Innovation in Finland. The opportunity to get financial support for R&D activities is obviously a reason for firms to exploit these instruments. Additionally, the involvement of research institutes and universities in the projects is another source of motivation because firms with similar R&D interests can combine their needs and (cost) effectively collaborate with research institutes and universities. Also, perhaps a lesser potential benefit is the possibility of getting publicity for the firm as an R&D-oriented actor, which can be accomplished through the various communication activities the projects and programs offer for its members. Furthermore, the process of applying for funding requires defining the R&D intentions explicitly, which otherwise might be left to the side, especially when small and medium-sized enterprises (SMEs) are concerned.

The current dissertation sheds light on interfirm collaboration in the context of R&D project networks. More closely, the factors hindering and facilitating interfirm knowledge transfer (KT) are viewed. The research data was gathered by interviewing firm representatives from firms participating R&D projects that were partly funded by Finnish public funding agency. The importance of social ties has been widely recognised in the literature as a potentially effective source of knowledge (Kwon and Adler, 2014); thus, social capital was chosen as the main theoretical lens for the categorisation of the research findings. Taken as a whole, the approach of the present study is explorative.

A motivation of the author to study this topic, besides the knowledge gap explained in the next chapter, is to emphasise the potential that lies in R&D projects concerning interfirm collaboration. Because projects offer funding for R&D activities and connections with research institutes, they can also be considered collaborative networks for firms in which business opportunities and new knowledge can be created. The author believes that this network perspective is often underestimated.

## 1.2 Knowledge gap and research questions

Despite the vast literature on interfirm collaboration in different contexts (e.g., strategic alliances, Lin et al., 2012; project alliances, Hietajärvi et al., 2016; supplier–customer relationships, Lawson and Potter, 2010; and industrial districts, Albino et

al., 1999), there seems to be a gap concerning research on interfirm collaboration in the context of R&D project networks. Previous studies of collaboration in R&D projects have focused on firm–research organisation/university relationships (e.g., Mitton et al., 2007; Siegel et al., 2004).

The above observations lead to two basic questions. First, what are the potential factors that affect interfirm collaboration in the context of R&D projects, that is, what features facilitate or hinder the collaboration? Second, should they be studied separately, that is, how unique R&D are project networks, or, in other words, does the existing research offer adequate understanding of interfirm collaboration in R&D project networks?

The intention to conduct this research by studying interfirm collaboration in the specific context of R&D projects was supported by the study of Inkpen and Tsang (2005); they compared preferable KT conditions in industrial districts, strategic alliances and in intracorporate networks, finding clear differences from a social capital perspective between the network types. This means that different network types are likely to have different characteristics, which may have a significant effect on the collaboration.

Based on the identified research gap, the current research was positioned to shed light on interfirm collaboration in R&D project networks. During the progression of the research, the present study focused on KT between firms. The hypothesis is that the theoretical framework of social capital is capable of explaining the extent of interfirm KT in the context of R&D project networks. The hypothesis is supported by previous literature that has recognised social capital as a suitable theoretical lens for studying KT circumstances in different contexts, for example, in supplier networks (Rottman, 2008), between universities and industry (Robertson et al., 2019), in teams (Wei et al., 2011) and in multinational companies (Zimmermann and Ravishankar, 2014). The research gap and hypothesis are observed through the following four research questions:

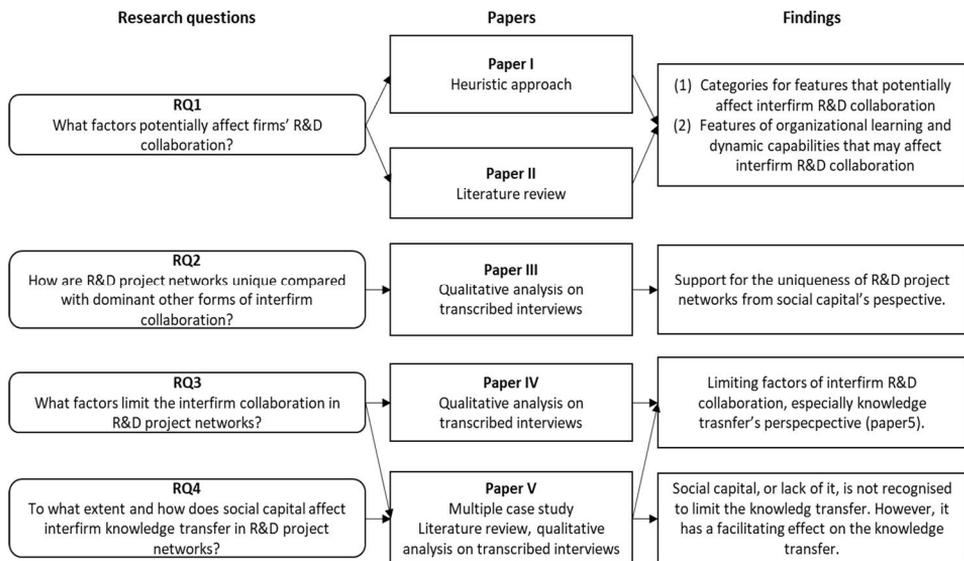
*Research question 1 (RQ1): What factors potentially affect firms' R&D collaboration?*

*Research question 2 (RQ2): How are R&D project networks unique compared with dominant other forms of interfirm collaboration?*

*Research question 3 (RQ3): What factors limit interfirm collaboration in R&D project networks?*

*Research question 4 (RQ4): To what extent and how does social capital affect interfirm KT in R&D project networks?*

**Figure 2** illustrates the connections among the research questions, papers included in the dissertation and related findings.



**Figure 2.** Research questions, methods, and findings.

### 1.3 Structure of the dissertation

The current dissertation comprises an introductory section and five scientific publications. The first chapter of the introductory section is the introduction, which presents the background of the study, identification of the research gap and formulation of research questions. Additionally, the structure of the dissertation is presented. The next chapter introduces the theoretical framework of the research. Brief reviews on research on knowledge-related topics and R&D collaboration in management literature are given. Also, the enablers and barriers of KT from previous literature and the concept of social capital are presented. The methodology of the research, including a description of the real-life context of the study and research validity are presented in chapter 3. Chapter 4 explains the findings of the study, here as organised according to the research questions. The final chapter discusses the results and their theoretical contributions. Additionally, implications for innovation policies and R&D project management are given, and directions for future research are provided.

The second part consists of the articles included in the dissertation. Papers 1, 3 and 4 were published in peer-reviewed scientific conferences, and papers 2 and 5

were published in journals. The author of the dissertation is the lead author of papers 1–4 and sole author of paper 5.

## 2 THEORETICAL FRAMEWORK

### 2.1 A brief review of R&D collaboration research in the management literature

In the modern, fast-changing business environment, firms need to constantly renew their capabilities and offerings. Often, this renewal requires R&D efforts. However, R&D can be slow, costly and ineffective, or it can lead to innovations that do not meet market needs or are not able to compete successfully against other products. A solution that potentially mitigates all the mentioned risks is R&D collaboration (Narula, 2001). In general, knowledge-intensive collaboration has a positive impact on firms' performance. These potential benefits have been noticed by firms because the amount of R&D collaboration has grown significantly over the last decades, especially in the 1980s (Hagedoorn, 2002).

From a research perspective, R&D collaboration can be both a fascinating but also challenging topic—and for the same reasons. First, there exist multiple potential research contexts because of the many forms that R&D collaboration can take. Second, within these contexts, the research can focus on numerous aspects, for example, the consequences and outcomes of R&D collaboration, features and circumstances of R&D collaboration, formation of R&D collaboration and facilitating and enabling this collaboration. Third, several scientific approaches and theoretical lenses can be used to explain the collaboration-related phenomenon in a chosen network context.

Context-wise, the determining variables are commonly associated with the questions of who is doing the R&D collaboration and how they are doing it. Regarding the former question, the research can, for example, focus on certain fields of business (e.g., in Reichman and Simpson, 2016), study collaboration between firms (e.g., in Lawson and Potter, 2010) or between firms and universities/research organisations (e.g., in Mitton et al., 2007). Regarding the latter question, the research may focus on certain types of networks or relationships. Hagedoorn (1990) classified modes of R&D collaboration based on the interdependence the firms have towards each other. In his classification, joint ventures and research corporations represent large interdependence as one-directional technology flows, and licensing represents

small interdependencies. One of the most, if not the most, studied forms of R&D collaboration is the R&D alliance, which was defined by Martinez-Noya and Narula (2018, p.196) as ‘innovation-based relationships formed by two or more partners who pool their resources and coordinate their activities to reach a common goal’. However, a lack of uniformity in definitions exists, and several other ‘names’ referring to similar collaborations have been used in the literature (Martinez-Noya and Narula, 2018), which, according to Martinez-Noya and Narula (2018) ‘reflects the multidisciplinary nature of the subject’.

Research has recognised several relevant aspects when it comes to studying R&D collaboration. Examples of these aspects and the related literature are given in **Table 1**. For clarity reasons, the aspects are divided into three categories: (1) formation of R&D collaboration, (2) activities and enablers during the collaboration and (3) outcomes and performance of R&D collaboration. The purpose of presenting these perspectives of R&D collaboration research is to demonstrate the multitude of various focuses in R&D collaboration that previous research has taken, not to provide an exhaustive list of possible research topics.

<b>Table 1.</b> Aspects and examples of research on R&D collaboration.	
Category	Aspects and examples from literature
Formation of R&D collaboration	R&D alliance formation (Reuer and Lahiri, 2014; Doz et al., 2000)
Activities and enablers of R&D collaboration	Knowledge transfer (Galati and Bigliardi, 2019; Inkpen and Tsang, 2005) Joint learning (Huikkola et al., 2013; Bäck and Kohtamäki, 2016) Success factors (Mora-Valentin et al., 2004; Littler et al., 1995) Governance (Choi and Contractor 2016; Carson et al., 2003; Oxley and Sampson, 2004)
Outcomes and performance of R&D collaboration	R&D performance (Czarnitzki et al., 2007; Belderbos et al., 2015) Product innovation (Un et al., 2010; Kang and Kang, 2010)

Besides the multiple aspects when it comes to studying R&D collaboration, several theoretical approaches in various disciplines have been used to deepen the understanding of R&D collaboration. However, because of the multidimensional nature of R&D collaboration, the theoretical approaches often draw from a variety of disciplines, meaning that the research is published in multidisciplinary journals.

Below, some theoretical approaches are presented, which in the literature have contributed to the research of R&D collaboration.

Several countries and regions encourage collaborative R&D between firms and between firms and universities. Thus, R&D collaboration is one of the focus areas in the field of science, technology and innovation policy research, which is defined by Morlacchi et al. (2009, p.572) as the ‘application of social science (whether economics, sociology, political science, organisational science, business and management science, or psychology) to the study of policy for science, technology and innovation’. For examples of studies in science, technology and innovation policy research on R&D collaboration, see Aldrich and Sasaki (1995) or Watanabe et al. (2003).

A perspective commonly used to study R&D collaboration and inter-organisational collaboration in general is governance. Governance studies on R&D collaboration tend to focus on the governance structures or modes of R&D collaboration (e.g., Oxley and Sampson, 2004; Hagedoorn et al., 2005). The interplay of relational and formal governance is another common topic of governance studies concerning networks, but instead of R&D collaboration, it typically focuses on studying supply networks (e.g., Yu et al., 2005; Lioliu et al., 2014). It is noteworthy that relational governance and social capital—the theoretical lens of the current dissertation—have common facets, such as norms and trust (relational governance, Poppo and Zenger, 2002; social capital, Inkpen and Tsang, 2005). However, relational governance studies focus mostly on trust’s significance in a collaboration (e.g., Zaheer and Venkraman, 1995; Claro et al., 2006), while social capital evaluates a typically wider spectrum of facets (see chapter 2.2).

After Henry Chesbrough’s book *Open Innovation: The New Imperative for Creating and Profiting from Technology* in 2003, the concept of open innovation gained popularity among scholars (Le et al., 2019). Open innovation includes three core processes: (1) outside-in process, (2) inside-out process and (3) coupled process (Enkel et al., 2009). In the open innovation literature, collaborative R&D activity is considered a coupled process (Enkel et al., 2009). According to Schroll and Mild (2012), typical questions presented in open innovation research are as follows: Why are companies using open innovation? To what extent is open innovation generally used by firms? What form of open innovation is used?

Whether intra- or interorganisational R&D, the knowledge-related processes form the core of R&D activities; thus, it is natural that R&D collaboration is among the topics of knowledge management studies (e.g., Galati and Bigliardi, 2019; Faems

et al., 2007). Knowledge management is viewed in more detail in chapter 2.2 as part of a review of knowledge-related research in the management literature.

## 2.2 A brief review on knowledge-related research in the management literature

Knowledge is widely recognised as a strategic asset of a firm; this view is emphasised in the knowledge-based view of a firm, which considers knowledge to be the most important strategic resource of a firm (Grant, 1996). The knowledge-based view is a continuum of the resource-based view, which was promoted by Edith Penrose's book *The Theory of the Growth of the Firm* in late 1959 (Alavi and Leidner, 2001). The resource-based view suggests that 'complex, specialised, tacit knowledge' is capable of creating a sustainable competitive advantage because knowledge of this nature is hard to copy (McEvily and Chakravarthy, 2002).

Dynamic capabilities is another theory that offers a means for firms to pursue a sustainable competitive advantage in the fast-changing business environment (Teece et al., 1997) and that recognises the importance of knowledge as a source of competitiveness. The structure of a firm's capabilities can be viewed hierarchically. The operational capabilities are used in the day-to-day business and capabilities, such as dynamic capabilities, deeper in the organisation are used to renew the operational capabilities (Winter, 2003; Felin et al., 2012). Several authors have highlighted the importance of knowledge-related processes and capabilities as enablers of dynamic capability. Teece (2007) connected knowledge management to firms' capacity to manage tangible and intangible assets. Pavlou and el Sawy (2011) named learning capability and ability as ways to embed new knowledge into the existing knowledge of the firm, here being sources of dynamic capability in the context of new product development. Helfat et al. (2007) studied the enablers of dynamic capabilities from management, acquisition and alliance perspectives. Among the four main enablers of dynamic capability they identified are relational capabilities, which are supported by interfirm knowledge-sharing routines. Dynamic capabilities theory is discussed in detail in paper 2.

Organisational learning theory studies knowledge-related processes such as knowledge creation, acquisition, transfer, and the integration of knowledge into existing knowledge (Jerez-Gomez et al., 2005). However, organisational learning does not have a commonly accepted single model (Fiol and Lyles, 1985), and existing theoretical frameworks remain separate (Crossan et al., 1999). Organisational

learning and dynamic capabilities have a strong theoretical connection. Like dynamic capabilities, organisational learning capability is also considered a source of a sustainable competitive advantage (Camison and Villar-Lopez, 2011), and thus, it contributes to a firm's ability to build operative capabilities (Kim, 1998). Zollo and Winter (2002) considered organisational learning to be a source of dynamic capability; Pavlou and Sawy (2011) included organisational learning in dynamic capabilities. Because knowledge is a central concept of organisational learning, various frameworks in organisational learning research are directly or indirectly related to knowledge. However, considering the focus of the current dissertation, the following aspects of organisational learning are worth highlighting. Zollo and Winter (2002) identified knowledge articulation and codifications as important elements of organisational learning. Jerez-Gomez et al. (2005) named KT and integration as one of the four capability areas to be evaluated as part of measuring a firm's overall organisational learning capability. Kim (1998) highlighted the importance of learning orientation as an enabler of a firm's ability to 'catch up' to its competitors. According to Kim (1998), the ability to acquire, share and use knowledge are central aspects of learning orientation. Organisational learning theory is discussed in detail in paper 2.

Knowledge management, according to Durst and Edvardsson (2012, p.880), studies the processes and structures that 'support different knowledge processes, such as transfer, storage and creation'. Grant and Baden-Fuller (1995, p.64) presented that the knowledge management literature views knowledge management through two distinct activities: (1) 'those (activities) that increase organisation's stock of knowledge' and (2) those 'that deploy existing knowledge to create value'. Alongside the 'processes and structures', the knowledge management literature also studies capabilities (Freeze and Kulkarni, 2007) and an organisation's cultural aspects (e.g. Intezari et al., 2017) as enablers of the knowledge management process.

The perspectives that researchers have towards knowledge vary, affecting the focus of knowledge management studies (Alavi and Leidner, 2001). Alavi and Leidner (2001) identified six perspectives on knowledge, of which the process perspective is closest to the topic of the current dissertation. In this case, according to Alavi and Leidner (2001, p.110), knowledge management research should focus on 'knowledge flow and the processes of creation, sharing, and distribution of knowledge'. The other five perspectives on knowledge are knowledge vis-à-vis data and information, state of mind, object, access to information and capability.

Besides focusing on one or more processes, the scopes of individual knowledge management studies vary based on the context in which knowledge-related processes

occur. In the network context, scholars have shown interest especially in strategic alliances. Meier (2011) identified 71 relevant articles concerning knowledge management in strategic alliances and identified four landmarks in this field of research: knowledge characteristics, partner characteristics, partner interaction and active knowledge management. One of Meier's findings from previous research was that KT was more often the topic of an article than the creation and application of knowledge.

Yet another central aspect of knowledge management concerns the tacitness and explicitness of the knowledge. In knowledge management, the definitions of tacit and explicit knowledge are typically based on Nonaka (1991) and Polanyi (1966). Based on these two authors, tacit knowledge is considered knowledge that is unformalized, subjective and difficult to communicate, whereas explicit knowledge is formalised and, thus, can be easily communicated. Nonaka (1991, 1994) explained that conversions between and within the two knowledge types leads to a 'spiral of knowledge', that is, the creation of new knowledge.

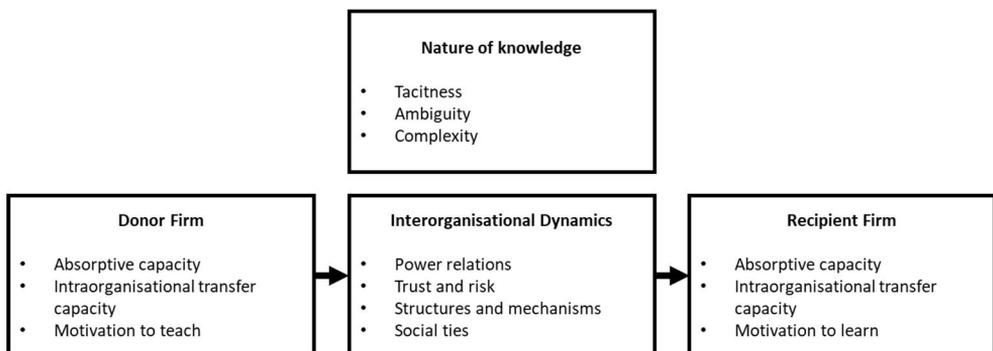
Considering R&D project networks and the formation of social capital, two aspects of knowledge conversion need to be highlighted. First, Nonaka (1994) emphasised the importance of shared experience when the tacit knowledge of a person is converted into the tacit knowledge of another person. In the context of R&D project networks, this means that the opportunities for the 'shared experiences' should be created, for example, through collaborative planning or analysis to facilitate the transfer of tacit knowledge. Second, Nonaka (1994) considered metaphors as a mean to facilitate the conversion of tacit knowledge into explicit knowledge. The metaphor is related to the facet of the shared language of social capital. The active interaction between members of an R&D network can lead to the network's 'own metaphors', which in turn can facilitate communicating complicated knowledge.

Related to manufacturing management, an interesting model on the demand-supply process from a knowledge perspective was presented by Fujimoto (2007). In the model, knowledge of market needs is transmitted to product development through, for example, marketing. Product development converts this knowledge into product plans, from which manufacturing transmits the knowledge into raw materials by manufacturing processes. The knowledge is further transferred to the market by using the product as the media. This illustration is a good example of how a knowledge perspective can be applied to illustrating processes that are not directly knowledge related.

## 2.3 Enablers and barriers of interorganisational KT

Based on the definition of Argote and Ingram (2000), Inkpen and Tsang (2005, p.149) defined KT in a network as a ‘process through which one network member is affected by the experience of another. Knowledge transfer manifests itself through changes in knowledge or performance of the recipient unit’. Easterby-Smith and Prieto. (2008) named improved innovation capability as a potential positive consequence of interfirm KT. Overall, interfirm KT is an opportunity for firms to strengthen their knowledge assets, thus improving their competitiveness.

Easterby-Smith and Prieto (2008) identified factors in four categories that affect KT between organisations (**Figure 3**): (1) nature of the knowledge being transferred, (2) donor firm’s resources and capabilities, (3) interorganisational dynamics and (4) recipient firm’s resources and capabilities. The following subchapters of chapter 2.3 give insights into the concepts of absorptive capacity, stickiness, distances, and embeddedness, which are commonly used in the research to explain interfirm KT. The concept of social capital is viewed in chapter 2.4, which is one level higher in the chapter hierarchy than other concepts, for two reasons. First, to emphasise its importance, social capital forms the main theoretical structure for categorising the research findings in the dissertation. Second, although social capital is often used to explain interfirm KT, it is not as ‘dedicated’ concept for this purpose as the other mentioned concepts.



**Figure 3.** Factor influencing inter-organisational knowledge transfer (based on figure by Easterby-Smith and Prieto, 2008, p.679).

### 2.3.1 Absorptive capacity

One of the most studied enablers of interfirm KT is absorptive capacity, which reflects a firm's ability to recognise the value of new external knowledge, assimilate the knowledge and apply the assimilated knowledge commercially (Cohen and Levinthal, 1990). Zahra and George (2002, p. 198) considered absorptive capacity as part of dynamic capabilities and defined it as a 'set of organisational routines and strategic processes by which firms acquire, assimilate, transform, and exploit knowledge for purpose of value creation'. In the model by Easterby-Smith and Prieto (2008), absorptive capacity is considered to be an important factor of KT, not only in recipient firms, but also in donor firms (see **Figure 3**) because 'the best teachers are often the best learners' (p.678).

Firms' absorptive capacity consists of two levels of capabilities—organisational and individual—and of the dynamic interplay between the two (Martinkenaite and Breunig, 2016). On the individual level, the employee orientation towards learning, ability to learn and civic virtue improve firms' overall absorptive capacity (Yao and Chang, 2017). On the organisational level, the following factors have been identified as sources of absorptive capacity: promotion of employee interaction (Zahra and George, 2002), prior knowledge base and social ties (Cohen and Levinthal, 1990), coordination capability of cross-functional interfaces, participation in decision making and job rotation (Jansen et al., 2005). For measuring a firm's absorptive capacity, Cohen and Levinthal (1990) suggested a simple model of dividing R&D expenses or personnel by sales. Here, higher results indicate higher absorptive capacity.

### 2.3.2 Stickiness

Knowledge can be 'sticky', meaning that transferring knowledge requires extra effort (von Hippel, 1994; Andersen, 1999). The extent of effort required to transfer the knowledge indicates the level of stickiness (von Hippel, 1994), or as Andersen (1999, p.627) stated, 'knowledge stickiness can be defined as the extent to which knowledge is unremovable from its originating source'.

Szulanski (1996) introduced the concept of internal stickiness to illustrate the difficulties related to intrafirm KT. The widely cited concept is based on Szulanski's analysis of the factors hindering a firm's ability to transfer best practices and related knowledge between units and people. Szulanski (1996) found that the lack of absorptive capacity, causal ambiguity and arduousness of the relationship are the

main sources of internal stickiness. He also emphasised the finding that the mentioned factors explain stickiness over motivation-related barriers. Here, absorptive capacity was defined rather narrowly. Szulanski (1996) considered absorptive capacity as mainly a function of pre-existing knowledge (see 2.3.1 for a wider perspective on absorptive capacity). Szulanski explained causal ambiguity as being present when reasons for the unsuccessful replication of knowledge are hard to identify. Further, Szulanski drew from Polanyi (1962) and Tyre and Von Hippel (1997), identifying the tacitness of human skills and knowledge, and different contexts in which knowledge is applied to potentially explain the causal ambiguity. By an arduous relationship, Szulanski means a 'laborious and distant' relationship, and drawing from Nonaka (1994), that knowledge with tacit qualities may require multiple transfers attempts to be successful. Considering the framework by Easterby-Smith and Prieto (2008) presented in **Figure 3**, the source of knowledge stickiness can be in any of the four aspects of the framework.

Knowledge stickiness has also been analysed in networks. Andersen (1999) studied how interpersonal exchange, electronic data interchange and formal contracting affect knowledge stickiness in international technological collaborations between contractors and subcontractors. The results imply that contracting and interpersonal exchange can be used to compensate for the stickiness of KT coming from geographical distance. Li (2012) investigated KT between buyers and suppliers, finding that social embeddedness and learning capability are important to moderate stickiness. Li (2012) also presented an interesting notion that stickiness can have both negative and positive effects on learning. The negative effect comes from the inability to accommodate capabilities according to customer requirements. However, the inability to learn from customer feedback can facilitate problem solving, thus affecting learning positively.

### 2.3.3 Distances

In this chapter, various aspects of similarity and distance and their effects on KT are discussed. Cummings and Tseng (2003) evaluated the effects of relational context on transferring R&D knowledge; they considered the relational context as emerging from the dimensions of organisational, physical, norm and knowledge distance between the firms. Their findings indicate that higher distances regarding norms and knowledge have a negative effect on KT. Although the distances can be evaluated only by first understanding the features of the knowledge donor and recipient, the

distance itself is an element of interorganisational dynamics (see **Figure 3** by Easterby-Smith and Prieto, 2008).

Cummings and Tseng (2003) connected the concept of organisational internalisation to organisational distance, that is, high internalisation means a lower distance (e.g., in intrafirm relationship) and low internalisation means a higher distance (e.g., in interfirm relationship). To define internalisation, Cummings and Tseng drew from Meyer and Rowan (1977) and referred to the extent of ownership, commitment, and satisfaction the recipient has towards the transferred knowledge. Hsiao et al. (2017) studied the effect of organisational distance on equity-based alliances and contract-based alliances, finding that as the distance increases, KT performance decreases in both network types, but the effect is stronger on equity-based alliances.

As physical—or geographical—distance increases, the interactions between parties may become more difficult. Meeting face-to-face becomes more expensive and time-consuming, and time differences can cause challenges when meeting online.

By knowledge distance, Cummings and Tseng (2003) referred to the knowledge overlap the parties have, meaning that very dissimilar knowledge bases may require too many ‘learning steps’ to have the knowledge transferred. However, a higher knowledge distance may simultaneously offer better opportunities for learning and innovation because more new knowledge is available for the parties (Gilsing et al., 2008).

To measure norm distance, Cummings and Tseng (2003, p.58) evaluated ‘the extent to which the parties share similar understandings and ideas about the knowledge transfer project’. Norm distance is related to the distance between the cultures of the network, which is a result of differences in organisational or national cultures. Ibert and Muller (2015) identified the following dimensions for the evaluation of cultural similarity: cognitive, organisational, institutional, social, functional and interest. In addition, they added hierarchical distance, which evaluates parties’ access to organisational resources and position in the organisation and institutional field.

Das and Teng (2003) made an important notion concerning the resourcing of collaboration. They argued that research typically focuses on an evaluation of the qualitative and quantitative similarity of partners’ resources on a firm level, but the actual resource utilisation should also be considered. Considering the effects that the various distances have on KT, a firm-level evaluation may give wrong impressions; for example, in the case of specific teams from two firms exchanging knowledge, the

evaluation of the norm distance between the teams may give significantly different results compared with an evaluation of the norm distance between firms.

### 2.3.4 Embeddedness

In this chapter, the concept of embeddedness is briefly presented. Embeddedness has been used from various perspectives to analyse KT and learning in interorganisational contexts. Uzzi's (1997) conceptualisation of embeddedness can be considered a seminal work when it comes to the use of embeddedness as an explanatory framework for interorganisational dynamics (see **Figure 3** by Easterby-Smith and Prieto, 2008). Uzzi and Lancaster (2003) described that in interfirm relationships, the level of embeddedness is the degree of social attachments embedded into the commercial interfirm ties. The higher the level of embeddedness, the more transfer of private knowledge and exploratory learning will occur in the relationships (Uzzi and Lancaster, 2003; Dhanaraj et al., 2004). Uzzi (1997) identified three main components for embeddedness of interfirm relationships: (1) trust, (2) fine-grained information transfer and (3) joint problem-solving arrangements.

Besides relational embeddedness, the effects of structural and knowledge embeddedness on KT have been studied. Hong and Nguyen (2009) studied knowledge embeddedness in multinational corporations, finding that more tailored KT mechanisms are needed when knowledge is embedded. By knowledge embeddedness, they meant the locality of the knowledge compared with the universality of the knowledge. Dayashindu (2001) studied relational and structural embeddedness in the Indian software industry. By structural embeddedness, Dayashindu (2001) was referring to the overall connectedness of the organisations, considering that this leads to diffusion of norms. According to Rowley et al. (2000), structural embeddedness is associated with network structure and such aspects as strength of ties, density of ties and structural holes (for structural holes, see, e.g., Burt, 1997).

## 2.4 Social capital

Although the concept of social capital has been considered somewhat problematic because of its multifaceted nature (Adam and Rončević, 2003), the research has

created a strong connection between social capital, its elements and the facilitation of interorganisational collaboration (e.g., relational capital in Collins and Hitt, 2006; social capital in Inkpen and Tsang, 2005; social capital in Laursen et al., 2012; social capital in Rottman, 2008; relational embeddedness in Uzzi and Lancaster, 2003; ties in Retzer et al., 2010; trust in Li, 2005).

In the management literature, social capital is often defined based on Burt (e.g., 1997) or Coleman (1988, 1990) (Payne et al., 2011). Burt's (1997) perspective centres on the external linkages and concept of structural holes (Adler and Kwon, 2002; Payne et al., 2011). Coleman (1988) considered social capital as consisting of multiple entities that represent the aspects of social structures and that facilitate actions within the structure. Another commonly referred definition for social capital is by Robert Putnam who considered social capital as the 'features of social organisations—such as trust, norms, and networks—that can improve the efficiency of society by facilitating coordinated actions' (1993, p.167). Compared with financial or intellectual capital, social capital differs because it is embedded in social constructs and other forms of capital belong to individuals or legal entities (Putnam, 1995).

Inkpen and Tsang (2005, p. 151) defined social capital as “the aggregate of resources embedded within, available through, and derived from the network of relationships possessed by an individual or organization.” This definition, slightly modified from the definition by Nahapiet and Ghoshal (1998), is used in the present study for three main reasons. First, this approach for social capital represents hybrid approach and does not make distinction between internal or external aspects of social capital (for more detailed view on internal, external, and hybrid approaches see paper five). As the purpose of this dissertation is to understand social capital's significance in the interfirm KT in R&D project networks, it is not purposeful to exclude internal or external aspects of social capital from analysis, as both types can affect the KT. Second, defining whether a specific feature of social capital is primarily a resource of an individual (external approach), firm (internal approach), or network (internal approach) can be difficult, if not impossible. In addition, they are interlinked and contribute to each other. Third, the approaches by Nahapiet and Ghoshal (1998), and Inkpen and Tsang (2005) have been effectively used in several studies similar to this one, that is, the instrumental value of social capital is viewed for the organization's or network's processes (e.g., Akhavan and Hosseini, 2016; Carey et al., 2011; van Dijk et al., 2016; Gooderham et al., 2011; Mäkelä and Brewster, 2009; Zheng et al., 2014).

Earlier work on social capital studied social capital as a unidimensional concept (e.g., Coleman, 1988; Burt, 1992). However, a three-dimensional model by Nahapiet

and Ghoshal (1998) has gained popularity among management scholars and is also adopted in the current study. According to Nahapiet and Ghoshal (1998), social capital consists of the structural, cognitive and relational dimensions (Figure 4). Li et al. (2013) considered structural social capital as supporting the formation of relational and cognitive social capital. However, Tsai and Ghoshal (1998) did not find the causality between structural and cognitive capitals as being significant. Additionally, cognitive social capital can positively affect relational social capital (Carey et al., 2010). Chapters 2.4.1–2.4.3 describe the features of social capital according to these three dimensions.

In the current study, the structure of social capital and the definitions of the features and facets of social are primarily based on the articles of Nahapiet and Ghoshal (1998) and Inkpen and Tsang (2005) (Figure 4). The articles have often been used as the basis for defining social capital in management studies over the last decade, for example, in Villena et al. (2011), Gooderham et al. (2011), Carey et al. (2011), Ansari et al. (2012), Li et al. (2013), Zheng et al. (2014), Akhavan and Hosseini (2016), Dijk et al. (2016) and Theodoraki et al. (2018).

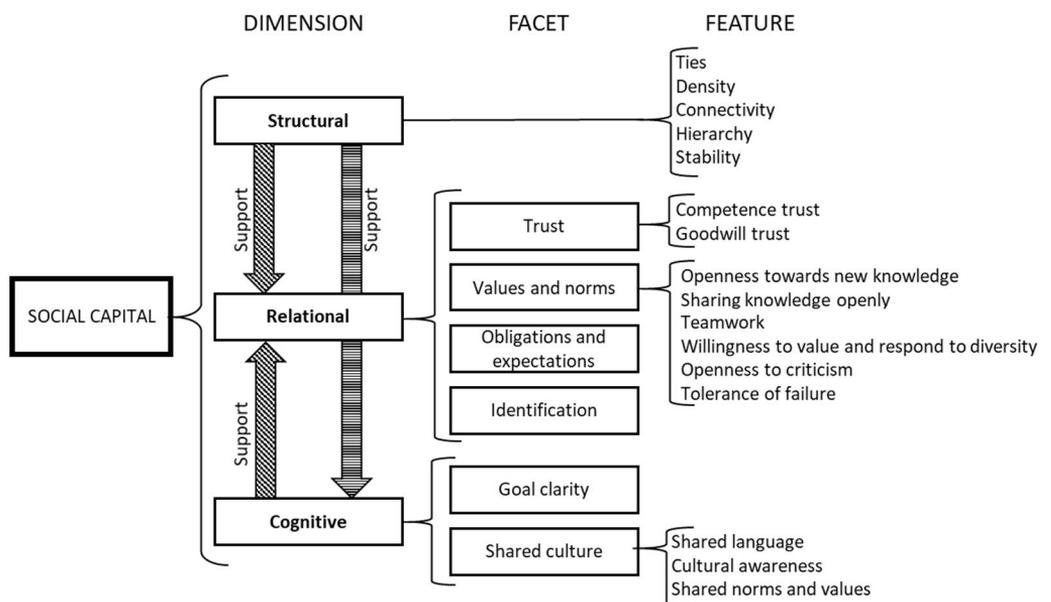


Figure 4. Social capital dimensions, facets, and features.

## 2.4.1 Structural social capital

Structural social capital illustrates the impersonal characteristics of social capital, especially the ‘pattern of connections between actors’ (Nahapiet and Ghoshal, 1998, p. 244), or as explained by Villena et al. (2011, p.563), ‘structural capital rests on the existence of connections and their configurations within a social structure’. Li et al. (2013) identified features such as ties, configuration, and density among people as the features of structural social capital, claiming that the scholars studying structural social capital have often considered it to predict relative and cognitive capital. The concepts of structural holes (see, e.g., Burt 2002) and centrality (Li et al., 2013) are often associated with structural social capital. In these concepts, individuals or firms may have a position in the network that connects otherwise weakly connected parts of the network together, thus gaining an individual or firm control over knowledge flows (Burt, 1992). The nature of social capital is multifaceted (see paper 5); thus, it is natural that research has not agreed on a conclusive list of elements that form structural social capital. To measure structural social capital in R&D teams, Akhavan and Hosseini (2016) evaluated the closeness of relationships, time spent in interactions and frequency of communication. To understand structural social capital, Kim et al. (2013) evaluated ‘the goodness’ of relationships and awareness of the importance and availability of knowledge among network members. Drawing from Nahapiet and Ghoshal (1998) and Inkpen and Tsang (2005), the following features are included in the structural social capital in the current thesis: ties, density, connectivity, hierarchy and stability.

Network **ties** are the connections between the network members. Drawing from Inkpen and Tsang (2005), the focus of the present thesis is on whether ties exist among people and/or organisations and how they strengthen the formation of each other. **Connectivity** refers to how well the ties cover the network, and **density** refers to the overall number of ties in the network. Although the density and connectivity are inter-related, the total number of ties may be high, making density high as well, but ties are limited to certain parts of the network, making the connectivity low. **Hierarchy** implies the power and authority the members high in hierarchy might have towards other members. In the current study, for example, the customer is considered to have some power over their suppliers’ R&D activities, especially if the suppliers’ R&D intentions are related to this customer relationship. Network **stability** refers to the extent to which changes in network memberships occur. Change may concern a new firm entering the network or one leaving the network. Also, changes in firm representatives reduce the networks’ stability.

## 2.4.2 Relational social capital

Relational social capital refers to the personal relationships between people. According to Nahapiet and Ghoshal (1998, p.244), relational social capital refers to ‘assets created and leveraged through relationships’ and explains an individual’s behaviour through social motives. Based on a meta-analysis of 75 journal articles, van Wijk et al. (2008) considered relational social capital to be the most important of the three dimensions of social capital for inter- and intraorganisational KT. Carey et al. (2011) found that cognitive and structural social capital positively influence the formation of relational social capital. When scholars evaluate relational social capital, trust is almost always included in these evaluations. Features such as norms (e.g., in Theodoraki et al., 2018; van Dijk et al., 2016; Sutanto, 2013; Weber and Weber, 2007), obligations (e.g., in Theodoraki et al., 2018), expectations (e.g., in Theodoraki et al., 2018) and identification (e.g., in Theodoraki et al., 2018; van Dijk et al., 2016; Akhavan and Hosseini, 2016; Sutanto, 2013) are also often considered part of relational social capital. The aforementioned features of social capital, especially norms and trust, are often referred to in governance studies, in which the relationship between formal and informal governance mechanisms is considered (e.g., in Poppo and Zenger, 2002; Cannon and Achrol, 2000; Carson et al., 2017). Adapted from Nahapiet and Ghoshal (1998), the following features of relational social capital are included in the current thesis: trust, norms, obligations and expectations and identification.

**Trust** can be viewed from two perspectives based on what is trusted: goodwill or competence of the instance that is being collaborated on (e.g., Ireland and Webb, 2007). In general, trust is associated with the expectations the trustor has towards the trustee (Simons and Peterson, 2000), that is, expecting certain behaviours to exist or not. Goodwill trust, or affective trust (McAllister, 1995), exists when the trustor believes that the trustee is concerned with the well-being of the trustor (Dirks and Ferrin, 2002) and will not behave opportunistically. Competence trust, or cognitive trust, refers to trust in the capabilities and reliability of the trustee (Schoorman et al., 2007).

According to Fehr and Fischbacher (2004, p.185), social **norms** are the ‘standards of behaviour that are based on widely shared beliefs how individual group members ought to behave in a given situation’. As norms represent context specific behavior, **values** are more generic by their nature and create guidelines for personal behavior (Bardi and Schwartz, 2003). It is noteworthy, that, although norms often manifest peoples’ values, an individual may act according to group’s norms that oppose

his/her own values (Bardi and Schwartz, 2003). The values and norms are considered here as single facet as it is often difficult, if not impossible, to separate these two.

The following norms, adapted from Nahapiet and Ghoshal (1998), are included in the study: openness towards new knowledge, sharing knowledge openly, teamwork, willingness to value and respect diversity, openness to criticism and tolerance of failure. Not sharing knowledge openly or the inability to acquire or exploit new knowledge may be explained by reasons that are not norm related, for example, protecting knowledge or having an insufficient knowledge base. However, sharing knowledge openly or having a positive attitude towards new knowledge can be behavioural standards of the network, creating social pressure to act according to these norms. Teamwork is itself a multifaceted norm. For simplicity, teamwork is defined here as the extent to which members work together on common tasks (Hoegl and Gemuenden, 2001).

The diversity of network members can enrich the knowledge pool because it increases the amount of potentially new knowledge to be transferred. However, diversity can also cause inefficiency when it comes to collaboration (Reagans and Zuckerman, 2001) because a certain amount of knowledge overlap is needed to transfer knowledge efficiently between members. An appreciation of diversity increases the willingness to invest the required time to overcome the challenges coming from the diversity of the network.

Receiving criticism can be emotionally difficult. However, the ability to receive—and even appreciate—critical feedback creates more opportunities for learning compared with only accepting positive comments. As a network norm, openness to criticism increases the likelihood of sharing analytical and critical thoughts within the network.

A certain amount of risk taking is present when something new is being created. In R&D project networks, intolerance of failures may lead to hiding mistakes, that is, not sharing the experiences of failures openly, which hides potentially valuable knowledge from the network.

In the context of social capital, **obligations** refer to feeling obligated, which is a result of the reciprocity and relational contracts between the network members (Rousseau, 1990). Nahapiet and Ghoshal (1998, p.255) defined obligation as a way to ‘represent commitment or duty to undertake some activity in the future’. The formation of obligations can be supported by **expecting** certain behaviours from other member(s). Also, feeling obligated to behave in a certain manner may create expectations that others do the same.

Expectations of the quality and quantity of created and shared knowledge are strengthened by **identification** with other network members (Nahapiet and Ghoshal, 1998). Ashforth and Mael (1989, p.20) explained identification as ‘perception of oneness with a group of persons’, and it ‘leads to activities that are congruent with the identity’. This identification can also be referred to as a ‘we-feeling’ or experience of community (Vaisey, 2007; Kwon and Adler, 2014).

### 2.4.3 Cognitive social capital

Adopted from Nahapiet and Ghoshal (1998) and Inkpen and Tsang (2005), cognitive social capital represents the features that provide shared meaning and understanding among network members. As Tsai and Ghoshal (1998, p.465) explained, cognitive social capital ‘is embodied in attributes like a shared code or a shared paradigm that facilitates a common understanding of collective goals and proper ways of acting in a social system’. Carey et al. (2011) measured the amount of cognitive social capital by evaluating the extent to which network members share values, goals, ambitions and visions. Additionally, as part of cognitive social capital, Carey et al. (2011) measured how often the parties agreed on what is in the best interest of the relationship. A shared language is also often considered a central feature of cognitive social capital (e.g., van Dijk et al., 2016; Wasko and Faraj, 2005; Theodoraki et al., 2018), which includes features such as shared narratives (e.g., in Theodoraki et al., 2018) and codes (Ansari et al., 2012). In order to categorize the features of the cognitive dimension, this study adopted from Inkpen and Tsang (2005) and Nahapiet and Ghoshal (1998) and used facets of goal clarity and shared culture.

**Clearly defined goals** prevent conflicts between the members by facilitating negotiative situations (Inkpen and Tsang, 2005). Clear goals can increase members’ commitment because these types of goals describe what to commit to and give guidelines on how to contribute to network activities. When goals are clearly stated on a member level, the visibility within the network is increased, and members can have more accurate expectations of each other’s intentions (Inkpen and Tsang, 2005).

In the current study, the features of shared language, values and norms and cultural awareness are included in the facet of **shared culture**. Shared language means that members have a shared understanding of the meaning of the used language. Differences may occur because of, for example, different career and educational backgrounds. The words and language start gaining more specific

meaning as the network members communicate together and form shared narratives for expression (Boland and Tenkasi, 1995; Nahapiet and Ghoshal, 1998). The shared values and norms (or shared cognitions, O'Reilly et al., 1991) of the network form easily if the individuals participating in the collaboration share the same values and norms to begin with. However, the values and norms may differ, which can create challenges in collaboration. Knowledge and understanding of different cultures, that is, culture awareness, helps mitigate these challenges because members can better anticipate each other's activities and will be more likely to understand somewhat questionable actions. However, the extent to which the shared norms and values facilitate collaboration depends on what the actual norms and values are.

## 2.5 Summary of theoretical framework

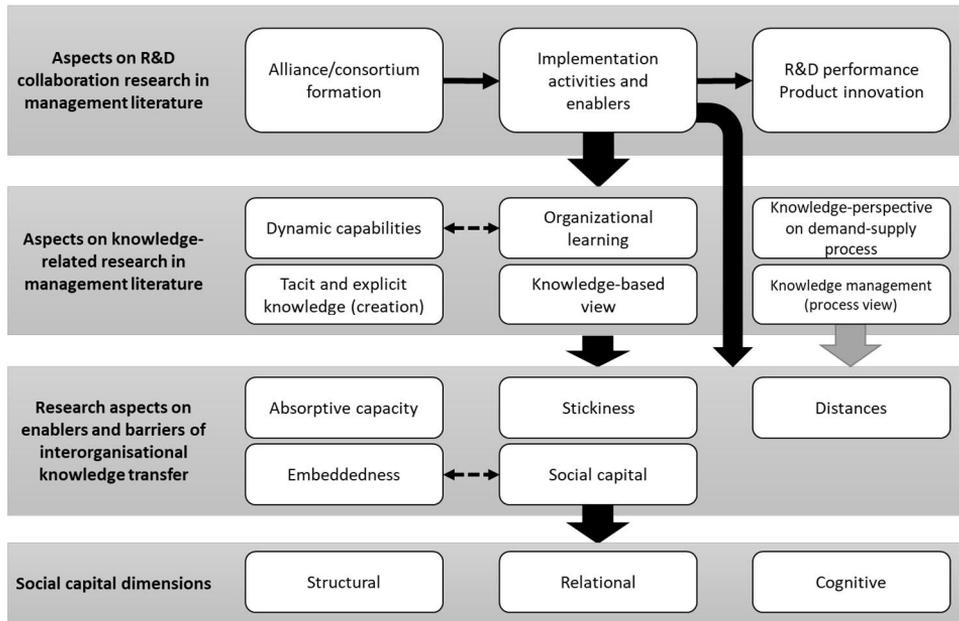
As this section covered multiple theoretical approaches to the studied phenomenon, a short summary of these approaches and their interconnectedness is here presented (**Figure 5**). However, most of these approaches are vast and multidimensional, thus also the interconnectedness can take numerous forms. Therefore, the summary focuses on those connections that perhaps are most central for this study.

The section 2.1 focused on approaches and aspects in management literature that are used for explaining the dynamics of R&D collaboration. Three separate areas of collaboration research were recognized: (1) Alliance/consortium formation, (2) Implementation activities, and (3) R&D performance and product innovation. In the first phase the grounds are created for the collaboration activities, which in turn directly lead (or not) to innovations. Knowledge transfer is one of the activities during the implementation phase and is in central role in creation of new products and in improving the overall R&D performance.

Six theoretical approaches were identified for knowledge-related research in management literature (Section 2.2). They have explanatory capability on the R&D collaboration activities as e.g. learning and collaborative knowledge creation are in the core of fruitful R&D collaboration. Of those approaches *dynamic capabilities* and *organisational learning* are often considered being strongly connected.

Research aspects on enablers and barriers of interorganisational knowledge transfer were discussed in section 2.3. They have a capability of creating insights into reasons why knowledge-related processes in collaborative context are successful or unsuccessful. The listed enablers and barriers are especially relevant for the knowledge management research when the process view of knowledge management

is emphasized. *Social capital* and *Embeddedness* have a strong connection, or even overlap, as in both theoretical frameworks features such as ties and trust are often studied. Figure 4 already illustrates the connections between social capital dimensions, and thus they are not presented or discussed here.



**Figure 5.** Summary of the research aspects.

# 3 METHODOLOGY

## 3.1 Research design

The research design is the ‘master plan’ (Zikmund et al., 2010) of the research, and it integrates research activities and objectives into logical entities. It is a strategy that gives the reasoning for the decisions made during the study.

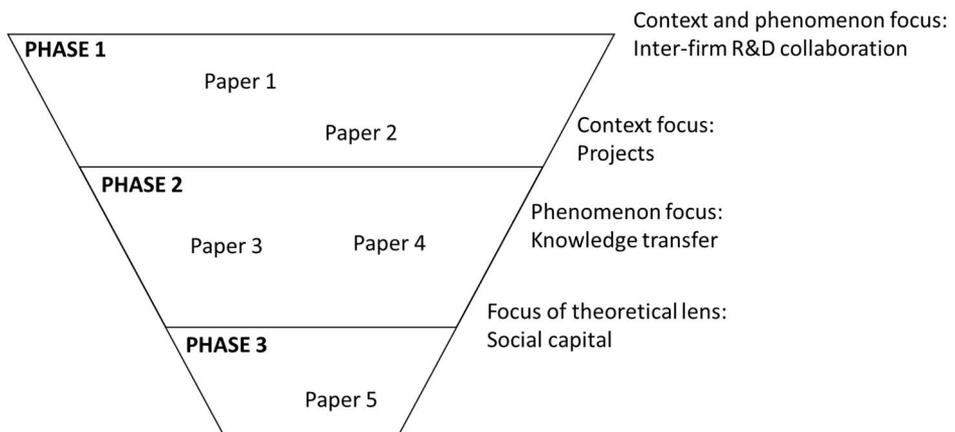
**Figure 5** illustrates the funnel-like progression of the current research. The research can be divided into three phases. In the first phase, an overall understanding of interfirm R&D enablers was built. A heuristic approach, with expert workshops and literature review, was chosen to support the fast progress of the research (paper 1.) To deepen the understanding of the R&D enablers of a firm, the literature on dynamic capabilities and organisational learning was reviewed (paper 2). As part of the studies in the first phase, it was identified that the literature rarely focuses on interfirm collaboration in the context of R&D projects.

In the second phase, the first goal was to evaluate how the R&D project networks differ from other network types. It was considered as a way to understand to what extent studies on other network types can explain the dynamics of R&D project networks (paper 3). The second goal of phase two was to gain context-specific knowledge on interfirm collaboration in R&D projects (paper 4). To meet these goals, in-depth interviews and a qualitative analysis of the transcribed interviews were conducted. This allowed for gathering rich data of the context (R&D project networks) and the phenomenon (interfirm R&D collaboration), thus enabling inductive and exploratory approaches, which are especially well-suited for exploring a specific, partially understood phenomenon (Kumar 2011, Eisenhardt and Graebner, 2007). During the second phase of the research, KT was identified as a significant manifestation of interfirm collaboration. For two main reasons, social capital was chosen as the main theoretical lens with which to evaluate KT enablers. First, its wide-ranging nature allows for the structuring the multifaceted findings. Second, previous studies have recognised its suitability for analysing KT enablers in various network types.

In the third phase, the objective was to deepen the context-specific understanding of interfirm KT in R&D project networks (paper 5). An in-depth look at social

capital's significance on KT' was carried out. A multiple case study method was chosen because of its suitability to study 'rich, real-world context in which the phenomenon occurs' and its ability to provide insights into complex social processes (Eisenhardt and Graebner, 2007, p. 25).

To support the case findings in third phase, a qualitative comparative analysis was conducted. Qualitative comparative analysis is a set-theoretic method to analyse causal conditions leading to certain outcomes. The KT or absence of KT were used as the outcomes for the analysis. First set of conditions consisted social capital dimensions. For the second set, social capital dimensions were combined into a single measure and conditions of *absence of limiting factors* and *motivation towards collaboration* were included in the evaluation. To exploit the rich qualitative data of the study a fuzzy-sets were used to express the presence of conditions in cases.

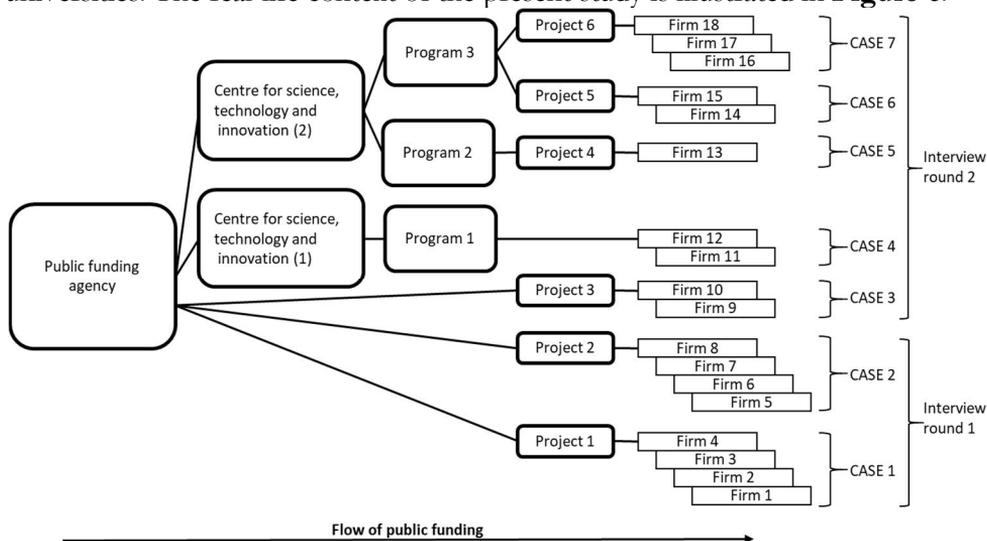


**Figure 6.** Funnel-like progress of the research.

### 3.2 Real-life context, data collection and analysis

Empirical data, which are used in papers 3, 4 and 5, were collected by interviewing the representatives of firms participating in collaborative R&D projects. All projects received funding from Finland's largest public funding agency for research, development and innovation. The typical share of public funding ranged from 25 to 30 percent. The total budgets for the projects ranged from hundreds of thousands to millions of euros. The firms represented a wide variety of businesses. However, the majority of the companies were from the machine building or information

technology sectors. All project consortiums included one or more research institutes or universities. The real-life context of the present study is illustrated in **Figure 6**.



**Figure 7.** Real-life context of the research, phases 2 and 3.

The interviews were conducted in two rounds. In the first round, the representatives of firms 1–8 were interviewed. The results from first interview round and subsequent analysis. are reported in paper 4.

The second round consisted of the representatives of firms 9–18. All the interviewees on both rounds were the main representatives of their employers in the projects. The interviews were executed between late 2015 and early 2017 in situations when the project had ended or was about to end. The interviews were semi-structured, meaning the interviewer had a list of questions but allowed for flexible answers. Also, follow-up questions were made. The author of the dissertation was the interviewer on all occasions. In the beginning of the interviews, the informants phased the project according to subobjectives and milestones of the project from their own perspective. The phases were illustrated on an Excel sheet, which was visible during the session. This seemed to help the informants remember the project events in more detail.

Each interview was recorded, resulting in 30 hours of recorded audio material. The recordings were transcribed word for word. The transcribed material was read through entirely three times, and several summaries were made. For the purposes of the study in paper 5, the material was organised as cases so that each project formed a case. A summary of the research methods is presented in **Table 2**.

It is worth noting, that the research related to paper 4 was conducted before the research related to papers 3 and 5, and thus only interview data from round 1 was available for the study reported in paper 4. From methodological perspective rounds 1 and 2 do not have impact, there was just more data available for the research reported in papers 3 and 5 compared to research reported in paper 4.

	PHASE 1		PHASE 2		PHASE 3
	Paper 1	Paper 2	Paper 3	Paper 4	Paper 5
Research question(s)	What factors potentially affect firms' collaborative R&D processes?		How are R&D project networks unique compared with dominant other forms of interfirm collaboration?	What factors limit interfirm collaboration in R&D project networks?	To what extent and how does social capital affect interfirm knowledge transfer in R&D project networks? What factors limit interfirm knowledge transfer in R&D project networks?
Theoretical framework	Multidisciplinary	Dynamic capabilities, organisational learning	Social capital (Knowledge transfer)	R&D collaboration	Knowledge transfer, social capital
Method	Heuristic approach	Literature review	Qualitative analysis of transcribed interviews	Qualitative analysis of transcribed interviews	A multiple case study
Data collection	Expert workshops	Literature	Interviews, rounds 1 and 2	Interviews, round 1	Interview data, rounds 1 and 2

### 3.3 Validity

I adopt categories of validity of qualitative research from Maxwell (1992) and evaluate the validity of the research from the perspectives of descriptive validity, interpretive validity, theoretical validity and generalisability. The validation of each perspective is presented in a separate paragraph of this chapter. Phases 2 and 3 are given special attention to for their qualitative nature.

Descriptive validity refers to the accuracy of what the researcher reports seeing or hearing at a certain moment when the data were gathered (Maxwell, 1992). In phase 1, the data were gathered through expert workshops and from the literature.

In expert workshops, the workshop participants could monitor the data gained during the workshop, which reduced the chance for misdescription. In reviewing the literature, author considered the validation of descriptive validity to be irrelevant as the process did not include reporting of something that was 'seen' or 'heard'. In phases 2 and 3, the data were gathered through interviews. Recording all the interviews increased the descriptive validity of the research. The transcriptions were conducted by an organisation with extensive experience in the field. Also, the phases of R&D projects (see 3.2.) were placed into Excel so that the interviewee was able to see and comment on the notes in real time.

Related to phases 2 and 3, the validity of interpretation has two dimensions in the current research: (1) how accurately the informants understood and reported the events of the R&D projects and (2) the accuracy of the interpretation of the research data. For both aspects, the multiple case study method in phase 3 helped tackle these challenges because according to Eisenhardt and Graebner (2007, p.27), 'multiple cases also create more [compared with a single case] robust theory because the propositions are more deeply grounded in varied empirical evidence'. Additionally, excluding the case 5, more than one source of data (informants) was used to describe each case. Although the multiple case method was not used until phase 3, a comparison between research in phases 2 and 3 was made, and conflicts were not identified. Regarding phase 1, the interpretation had a very minor role because empirical data were not used.

Because the descriptive and interpretive validity are about accuracy, theoretical validity views meanings and focuses on the theoretical concepts and their relationships, for example, causalities (Maxwell, 1992). The question of the theoretical concepts and their relationships is the most relevant in the research reported in papers 3 (phase 2) and 5 (phase 3), in which the concept of social capital was used to identify and structure the factors facilitating interfirm KT. The literature has accepted social capital as a theoretical framework to study the enabling of KT (see chapter 2.2.). In this sense, choosing social capital as the theoretical lens of the current research would be theoretically valid. However, structuring the research findings according to social capital features was not always straightforward work. To avoid misallocating the findings, a detailed description of social capital features was created (see paper 5 and chapter 2.2.). Also, the research data were read carefully several times, and multiple summaries of the data were made to obtain an accurate understanding of the conditions of R&D collaboration.

Generalisability means the extent to which the results can be applied outside of the directly studied phenomenon (Maxwell, 1992), which is strongly affected by the

level of specificity of the studied circumstances and events. The research reported in the dissertation studied R&D project networks consisting only of Finnish companies. This can create a specific setting in which similar backgrounds of informants, for example, education-wise, fastens the accumulation of social capital. Also, some features of social capital can be at a 'high level' when the project starts (e.g., shared language). Furthermore, Finland is a small country with 'small circles', which affects trust formation (for more detail, see chapter 5.1.). The business sectors represented in the current study are mostly from information technology and machine building.

# 4 RESULTS

The following chapters present the research results. The chapters are organised according to the four research questions of the dissertation (see chapter 1.2). The paper(s) in which the research results are presented in more detail are referred to in each chapter.

## 4.1 Capabilities of interfirm R&D collaboration

*Research Question 1 (RQ1): What factors potentially affect firms' R&D collaboration?*

The research presented in papers 1 and 2 contributes to answering research question 1. The capabilities that support the SMEs' ability to innovate in collaboration are illustrated in paper 1. Our research team recognised close to 100 capabilities that potentially affect the performance of the collaborative innovation process, that is, from generating ideas to commercial deployment and further development. The foundations for capability identification were created in earlier research, in which a method for strategic capability evaluation was created in active collaboration with firms from the manufacturing industry (see Halme et al., 2015). The identified capabilities were divided into the following categories:

- Interaction and knowledge sharing
- Information acquisition and refining
- Management and leadership
- Values and principles
- Technology
- Processes and practices
- Know-how and skills

Also, the steps typical of the innovation process in manufacturing industry were formed in workshops, and the significance of each capability category in certain steps was evaluated (**Figure 7**). The results of paper 1 are conceptual by their very nature, and they built a basis for the further steps of the research, for example, as guidance

for data gathering. The importance of knowledge management related capabilities was clearly recognised. Additionally, identification of the category of ‘values and principles’ guided the research towards using social capital as the theoretical framework for latter phases of the study.

<i>Process steps</i>	Generating ideas	Evaluation of ideas	Assessment of impact	Planning and development	Internal marketing	Piloting	Deployment	Monitoring and evaluation
<i>Capability categories</i>								
Interaction and knowledge sharing	x	xx	XX	x	xx	x	XX	
Information acquisition and refining	XX	x	x	xx		xx		XX
Management and leadership	x	xx	xx	x	xx	x	x	x
Values and principles	xx	x		xx	XX	x	x	x
Technology		x		xx		xx	xx	x
Processes and practices	x	xx	x	XX	x	x	xx	x
Know-how and skills	x	XX	x	x	xx	XX	x	

Legend XX the most critical capability group in a certain innovation process step  
 xx capability groups with high importance  
 x important capability groups

**Figure 8.** Significance of various capabilities in the different phases of the collaborative innovation process.

Paper 2 addresses RQ1 through two well-established theories: dynamic capabilities (DC) and organisational learning (OL). Based on a literature review, an introduction to both theories was given, and their connection to capability building was explained. Additionally, the evolutions of the theories were explained, and the so-called microfoundations of these theories were given.

Both theories explain firms’ ability to renew their operational routines and offer the means for a firm to achieve a sustainable competitive advantage in a constantly changing business environment (for dynamic capabilities, see, e.g., Teece, 2007; for OL, see, e.g., Camison and Villar-Lopez, 2011).

Although the direct purpose of DC and OL is not to identify or explain the factors affecting collaborative R&D, there are obvious intersections. Like DC and OL, the R&D activities were also about renewal; thereby, the enablers of DC and OL were mostly also enablers of R&D, at least indirectly. However, the author wants to highlight the following enablers recognised in the DC literature as some of the potential factors affecting firms’ ability to conduct successful collaborative R&D:

- Integrating, sensing and coordinating capability (Pavlou and El Saway, 2011)
- Capacity to seize opportunities (Teece, 2007)

- Relational and managerial capabilities (Helfat et al., 2007)
- Organisational structure (Felin et al., 2012)

Similarly, enablers recognised in OL literature are as follows:

- Knowledge articulation and codification (Zollo and Winter, 2002)
- Interpreting and institutionalising (Crossan et al., 1999)
- Openness and experimentation, KT and integration (Jerez-Comez et al., 2005)
- Absorptive capacity, learning orientation (Kim, 1998)

## 4.2 Uniqueness of firms' R&D project networks

*Research question 2 (RQ2): How are R&D project networks unique compared with dominant other forms of interfirm collaboration?*

An evaluation of the uniqueness of the R&D project network as a network type from a social capital perspective was reported in paper 3. Based on the results of the first interview round, the social capital elements in R&D project networks were identified and compared with the social capital elements of strategic alliances as defined by Inkpen and Tsang (2005) (**Table 3**).

Social capital dimension	R&D project network	Strategic alliances (Inkpen and Tsang, 2005)
Structural: Network ties	Intermember and social ties support each other	Intermember ties determining social ties within an alliance
Structural: Network configuration	Nonhierarchical, significant variation in connectivity and density	Nonhierarchical, possibility of exploiting structural hole positions
Structural: Network stability	Stable memberships	High rate of instability
Cognitive: Shared goal	Shared written goals that may not be internalised by the members. Goals rarely common.	Compatible goals but rarely common goals
Cognitive: Shared culture	Firm representatives' adaptation to network's culture	Cultural compromise/conflict among members
Relational: Trust	Low risk of opportunism. Trust formation supported by absence of competitors, NDAs and 'small circles'	Significant risk of opportunism, behavioural-based trust

The major social capital-related differences between the R&D project networks and strategic alliances were found to be in ‘network stability’, ‘shared culture’ and in ‘trust’. The unique feature of R&D project networks was that the duration of their existence is fixed. Naturally, R&D projects can be implemented in other network types, for example, R&D alliances or industrial districts, but in these situations, the networks would exist before the project, so the project would be built for the network. In the studied R&D project networks, the order of progress was found to be reversed because consortiums were built for the project. In the studied cases, most of the members did not have a previous history of collaboration. This meant that social capital started to accumulate not until the planning or even execution phase of the project. Based on this observation, the R&D project networks seemed to be network types ‘of their own’, at least from the perspective of social capital dynamics.

### 4.3 Limitations of interfirm collaboration in R&D projects

*Research question 3: What factors limit interfirm collaboration and KT in R&D project networks?*

The first round of interviews consisted of informants 1–8, focusing on an evaluation of the quantity and quality of the collaboration the firms had with universities/research institutes and other firms. A summary of the results (**Figure 8**) is presented in paper 4. Letter C refers to informant and firm. The subsectors under each informant refer to project phases identified by the informant during the interview. The collaboration between the firms and universities/research institutes is included in **Figure 8**, which provides an interesting benchmark of the firms’ overall willingness to engage in interorganisational collaboration.

	C1	C2	C3	C4	C5	C6	C7	C8
The amount of the collaboration with research institutes 0=none, 1=little, 2=moderately, 3=plenty	0 3 3 0	0 2 3 1 1 0	3 1 0 1 3 0	2 0 3 0 2	1 2 2 2 2 2	1 1 0 3 2 1 2 0	3 0 1 0	
The quality of the collaboration with research institutes 0=poor, 1=moderate 2= high	2 2	2 2 2 2	2 2 0 1	2 2	2 2 2 2 2 2 3 1 1	2 1 0 2	1 1	
The amount of the collaboration with other companies in the project 0=none, 1=little, 2=moderately, 3=plenty	0 0 1 0	0 0 0 0 0 0	3 1 0 1 3 0	0 0 0 0 2 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0			
The quality of the collaboration with other companies in the project 0=poor, 1=moderate 2= high	2		2 2 2 2	2				
Goal achievement 0=not achieved, 1=achieved partially, 2= achieved well	2 1 2	0 1 2 2 2 1 2	2 2 0 0 1 2 0	0 2 0 2 2 2 2 2 2 1 1 2 1 2 2 2 1 2 2				

**Figure 9.** Quality and quantity of collaboration, firms/informants 1–8.

The amount of interfirm collaboration was low, but when present, the quality was good. Here, ‘quality’ refers to the smoothness of the collaboration. Because of the lower-than-expected amount of collaboration between the firms, the data analysis focused on the identification of the factors that limited their collaboration. These factors were further allocated into three categories: (1) own R&D goal differed from the goals of other network members; (2) the project consortium changed into less synergetic; and (3) a qualitative or quantitative lack of resources.

At a later phase of the research, the focus narrowed from collaboration to interfirm KT, and a multiple case approach was taken. The limiting factors of KT during the project execution were recognised in cases 1–7 and were reported in paper 5. **Table 4** summarises these findings on a case-by-case basis.

<b>Table 4.</b> Reasons limiting the collaboration in cases 1–7.							
	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7
Issues related to the social capital	-	-	-	-	-	-	-
Potential member left the consortium	yes	yes	-	-	-	-	-
Changes in project length/budget	-	-	-	-	-	yes	-
Differences in R&D interests	yes	yes	-	-	yes	-	-
R&D goals were achievable alone and/or with research institute	-	yes	-	yes	-	-	yes
Lack of resources/resourcing	yes	yes	-	-	-	yes	-

## 4.4 Social capital effects on interfirm knowledge transfer in R&D project networks

*Research question 4 (RQ4): To what extent and how does social capital affect interfirm KT in R&D project networks?*

To answer research RQ4, a total of 18 informants from seven projects were interviewed. Each project was viewed as a case study. A summary of the cases from the perspectives of KT platforms and KT benefits is presented in **Table 5**. The following three chapters answer research question 4 based on the results presented in paper 5. The chapters are organised according to the three dimensions of social capital: structural, relational and cognitive.

<b>Table 5.</b> Perceived benefits from interfirm knowledge transfer, and knowledge transfer platforms.								
		Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7
Benefits from knowledge transfer	Getting feedback for individual R&D plans/results	no	no	yes	yes	yes	yes	yes
	Deepening supplier/customer understanding	no	no	no	no	yes	yes	no
	Collaborative business planning	no	no	yes	no	no	no	yes
	Learning from the R&D results of other firms and collaborative R&D	no						
	Learning from others outside of the project scope	no	no	yes	no	no	no	no
Knowledge transfer platforms	Knowledge shared in steering group meetings	yes						
	Knowledge shared in other coordinated project platforms	no	no	no	yes	no	yes	yes
	Knowledge exchanged outside of coordinated platforms	no	no	yes	no	no	yes	yes

#### 4.4.1 Significance of structural social capital to knowledge transfer

Structural social capital focuses on the impersonal features of social capital (Nahapiet and Ghoshal, 1998). The following network attributes were evaluated as features of structural social capital in the current study: ties, density, connectivity, hierarchy and stability (adapted from Nahapiet and Ghoshal, 1998 and Inkpen and Tsang, 2005).

Regarding the ties between firms, hierarchies, the density of the ties and interfirm connectivity, the differences between networks were small. However, in two consortiums some network members formed a so-called core groups in which the company representatives interacted actively. These strong personal ties between individuals seemed to stimulate KT. The overall stability of the networks was high. Only in case 7 did the consortium change during the project, which occurred when a new member joined the network during the execution phase of the project. This had no observable effects on KT. In two cases, the informants considered that a change of a firm representative limited KT. However, the limitations to KT were not a consequence of decreased social capital but because of the different R&D and business intentions the new representatives had, which led to decreased motivation towards collaboration.

The findings from qualitative comparative analysis clearly emphasized the significance of structural social capital to KT over other social capital dimensions. This is explained by the active KT in cases in which the core-groups were formed, which in turn led to high a level of structural social capital.

#### 4.4.2 Significance of relational social capital to knowledge transfer

Relational social capital observes the features related to personal relationships among people (Nahapiet and Ghoshal, 1998). The following facets of relational social capital were included in the current study: trust, norms, obligations and expectations and identification (identified as facets of relational social capital by Nahapiet and Ghoshal, 1998).

A lack of trust was not reported as limiting KT. However, in three cases, trust among the members was considered a facilitator of open sharing of knowledge. Yet this did not automatically lead to more beneficial KT among the members. The presence of competitors did not limit the formation of trust although the absence of competitors was mentioned as a facilitator of trust formation.

Norms form a vast entity. The following features of norms and their effects on KT were examined: sharing knowledge openly, openness towards new knowledge,

openness to criticism, teamwork, willingness to value and respond to diversity and tolerance of failure.

The firms shared their individual R&D results openly in all studied cases. However, hearing the R&D results was not considered to be particularly useful, and the firms did not exploit the shared R&D experiences in their own R&D. This was hardly because of a generic unwillingness to exploit new knowledge coming from other members because the collaboration with research institutes and universities was active and found to be beneficial. However, sharing the results allowed firms to get feedback on their R&D activities, which encouraged the firms to continue with the R&D choices they had made. This indicates that the firms were open to feedback. However, the criticality of the feedback is uncertain, and thus, conclusions related to the feature of ‘openness to criticism’ cannot be made.

In cases 3 and 7, a so-called core group formed around a common business interest. In these core groups, firm representatives worked as a team, and KT was active. In these cases, the informants expressed their appreciation of the network’s diversity because the core group members represented different industry fields. Overall, the diversity of the networks varied based on the firm sizes, positions in value chains and fields of businesses. This had no observable negative effects on KT. Whether the firms had ‘tolerance for failures’ cannot be evaluated because no actual failures were reported. In cases 3 and 4, the facet of ‘obligations and expectations’ was identifiable because the informants reported it as stimulating R&D activities. However, whether this affected KT is unclear.

The identification was not brought up directly, but in case 4 and in the so-called core groups of cases 3 and 7, the informants often referred to actions they were able to take as a group. In case 4, the ‘we’ was used in relation to the open sharing of the results, and in cases 3 and 7, it referred to the actions the groups took together. Firms identifying with each other seem to facilitate coactivities in the networks but not necessarily interfirm KT.

#### 4.4.3 Significance of cognitive social capital to knowledge transfer

Adapted from Nahapiet and Ghoshal (1998) and Inkpen and Tsang (2005), the dimension of cognitive social capital was defined in paper 5 as follows: ‘the cognitive dimension of social capital represents network features that support shared meaning and understanding among network members. Based on Inkpen and Tsang (2005),

facets of goal clarity and shared culture were used to evaluate the cognitive social capital in the networks.

In R&D project networks, a certain level of goal clarity came from the project plans that were required as part of the funding application process. However, it is worth noting that this did not mean that the goals were always focused. In several cases, the project-level goals were intentionally loosely defined to fit the R&D goals of individual firms under the same project-level goal. Goal clarity did not stand out as a network feature affecting KT. However, in case 3, an informant stated that the clarity of the roles facilitated KT. In case 6, the unclarity of the roles was reported by one informant as hindering KT.

The facet of shared culture was divided into the features of shared language, cultural awareness, shared norms and shared values. None of the features was reported to cause any challenges to KT, nor were these features identifiable as factors that facilitated KT. However, the importance of shared language was noticed by the firms, as in case 6, where the definitions for the core terminology were created by a subgroup of the network.

# 5 DISCUSSION

## 5.1 Theoretical contributions

A research gap concerning interfirm collaboration in the context of R&D projects was addressed through four research questions; the questions were answered in five papers. The early phases of the research focused on understanding the multifaced nature of R&D collaboration (papers 1 and 2) and progressed to study the uniqueness of R&D projects as a specific network type (paper 3). In paper 4, the extent of interfirm collaboration was evaluated. Additionally, papers 4 and 5 recognised the factors that hinder interfirm collaboration and KT. In the final phase, the current research studied interfirm KT in R&D projects through the theoretical lens of social capital, producing the main contributions of the research. The findings of the final phase are reported in paper 5

The first research question is as follows: *What factors potentially affect firms' R&D collaboration?* The question is answered in papers 1 and 2. In the research reported in paper 1, a heuristic approach was chosen for an agile recognition of the potential factors. Also, the approach was chosen for the early stage of the research to investigate the phenomenon without running into the potential limitations of specific theoretical frameworks. Close to 100 potential factors affecting R&D collaboration were recognised in the expert workshops, and they were divided into seven categories: 1. interaction and knowledge sharing, 2. information acquisition and refining, 3. management and leadership, 4. values and principles, 5. technology, 6. processes and practices and 7. know-how and skills. Paper 2 reports on an organisation's ability to build capabilities from the perspectives of dynamic capabilities and OL. The study was conducted as a literature review, and multiple so-called microfoundations of dynamic capabilities and OL were found. The factors of both theories that the author evaluated to be especially relevant for R&D collaboration are listed in chapter 4.1. Papers 1 and 2 contribute to the literature by emphasising the vast variety of factors that potentially affect R&D collaboration and by offering potential approaches to further study the dynamics of R&D collaboration.

The second research question is as follows: *How are R&D project networks unique compared with dominant other forms of interfirm collaboration?* To answer the question, the social capital characteristics of R&D project networks were recognised and compared with the social capital characteristics of strategic alliances. R&D project networks differ from strategic alliances in several features of social capital. The very nature of R&D project networks is unique because the networks are built for the projects, while in other network types, the projects are built by the networks. These findings contribute to theory by suggesting that research findings focusing on other network types may not be enough to explain interfirm collaboration in the context of R&D project networks. These findings are reported in paper 3.

The third research question is as follows: *What factors limit interfirm collaboration and KT in R&D project networks?* The limiting factors were recognised from seven R&D projects and reported in papers 4 and 5 and in chapter 4.3 of the current thesis. Most of the limiting factors identified are related to a lack of motivation the firms had towards the knowledge of other network members, which is consistent with the findings of previous studies (e.g., Szulanski, 1996; Osterloh and Frey, 2000). The findings related to the research question contribute to theory by identifying the factors that can limit interfirm KT in the context of R&D project networks. These factors should be considered as so-called primary factors because they can independently limit KT. It is noteworthy that social capital-related features are not among these factors. However, the lack of clarity of network members' roles was considered in one case by one informant as limiting KT. Role clarity was not identified as a social capital feature in the literature review of the current dissertation, but in terms of its meaning, it might be considered as such in future research.

The fourth research question is as follows: *To what extent and how does social capital affect interfirm KT in R&D project networks?* The question was answered in paper 5, which is based on a qualitative multiple case study of seven R&D projects. The findings suggest that all three dimensions of social capital can facilitate interfirm KT. However, the facilitative strength of social capital depends on the motivation the network members have towards collaboration. The main source of motivation towards collaboration is the shared business intentions. The result is supported by the in-depth case analysis as well as by the qualitative comparative analysis.

In the structural dimension, personal ties were recognised as facilitating KT. The relational social capital features of diversity and teamwork facilitated KT and potential identification with other members. It is noteworthy that in all projects, the individual R&D results were shared openly, but this did not facilitate KT. Also, trust was reported as being present in several cases, and here, the enablers of trust were

recognised, but trust did not seem to facilitate KT nor did a lack of trust limit KT. Considering the multiple studies emphasising trust's significance for KT in various circumstances (e.g., intrafirm, Levin and Cross, 2004; between universities and industry, Santoro and Saporito, 2006; buyer–supplier relationships, Squire et al., 2009), the finding was rather surprising.

The findings regarding research question 4 contribute to theory by identifying the features that facilitate interfirm KT in the context of R&D project networks. Naturally, if the present study was conducted in different environment, other features of social capital might also emerge. However, it is recommended that future research explaining interfirm KT with social capital take into account the potential of the features identified in the current study. The findings somewhat support the findings of van Wijk et al. (2008), who considered relational social capital to be the most important dimension of social capital in the facilitation of KT.

The main theoretical contribution of the current study concerns the mixed role of social capital in interfirm KT in the R&D project networks, as reported in papers 4 and 5. Several features in all three dimensions of social capital facilitated interfirm KT in the studied networks. However, while several causes limiting KT were identified, none of them were related to social capital.

**The findings indicate that social capital does facilitate KT in R&D project networks, but it needs to be accompanied by shared business intentions in order to obtain the most beneficial outcomes. In addition, the so-called limiting factors (see Table 4.) can mitigate the facilitative influence of social capital.**

A potential explanation for the non-critical role of social capital can be found in the unique features of this network type, from the characteristics of Finnish society and business circles and from the nature of social capital or knowledge. Concerning the network type, the main motivation to join the R&D project networks may very well not be because of possibility for interfirm collaboration, but, for example, be because of collaboration with research partners or gaining public funding. As Ansari et al. (2012, p.823) expressed: 'the ability to change knowledge, however, does not necessarily translate into the willingness to exchange knowledge'. In many network types (e.g., strategic alliances or supply chains), the very reason for joining the network is to collaborate with other firms, and the firms' goals may be interdependent. This means that in other network types, the motivation towards collaboration already exists when the network becomes operational, which

emphasises the importance of nonmotivational factors such as social capital. In R&D project networks, the motivation needs to be built during the existence of the project. If the motivation-related requirements are not met, the significance of social capital becomes less important or even irrelevant.

All studied cases included only Finnish firms, and all the informants were native Finns, which may explain why social capital did not arise in the research as a critical facilitator of KT. Finland has a low population, about 5.5 million, meaning that so-called circles in specific fields of businesses are small. Also, the educational system in Finland is rather homogenic. These factors may create circumstances in which certain behaviours are taken for granted or come naturally, in turn allowing for an easy accumulation of social capital. Thus, the facilitating impact of social capital gets unnoticed or is rarely noticed as limiting KT. Also, small circles are capable of creating a special circumstance concerning trust. It was known by the project network members that misbehaviour in the collaboration could cause serious and widespread damage to their reputation. Indeed, they were aware that others would not take this risk easily and, thus, were able to trust their behaviour, even without a previous history of collaboration.

In most of the studied cases, the project topics were technical, so the transferred knowledge—or the knowledge that could have been transferred—was mostly codified. Compared with knowledge with a more tacit nature, transferring codified or explicit knowledge depends less on the features of social capital (Dhanaraj and Steensma, 2004); thus, social capital's overall significance to KT was moderate.

Besides the identified knowledge gap (in chapter 1.2.), the motivation of the author to study interfirm collaboration in R&D project networks was to raise interest in the phenomenon in this specific context. Considering the potential benefits gained through collaboration described in the literature, the perceived benefits resulting from collaboration—and more specifically from interfirm KT—seem modest in R&D project networks (see **Table 5**). However, the author is not aware of the reasons emerging from this form of cooperation that would inevitably prevent firms from gaining benefits similar to other network types. However, what is noteworthy is the great variety of factors that can limit the collaboration and, thus, the benefits gained through it. Similarly, there is a large variety of enablers that may be required for collaboration or factors that facilitate the collaboration.

Besides identifying the factors affecting the collaboration and understanding the effect mechanisms, the author believes that the challenge, from both practical (e.g., project/network coordination) and academic perspectives, is to understand their interdependencies and hierarchies. The hierarchical perspective has a similar analogy

as capabilities, which are seen as forming a hierarchical structure (e.g., in Winter, 2003). Likewise, in the capability structure, certain network conditions or firm-specific capabilities are required before other, more operational conditions or capabilities can allow for collaboration. A simplified version—and perhaps more suitable for the guidance of project network coordination—would be to emphasise the importance of recognition of a collaboration bottleneck. This bottleneck can be something relatively obvious, such as a lack of resources from a quantitative perspective or something that lies deeper in the network, such as the unclear roles of network members that result in wrong or fuzzy expectations.

The awareness of a multitude of potential factors affecting collaboration and understanding their mutual dynamics can be irrelevant without the right intentions and motivations. This concerns the intentions and motivation of the network members, the network coordination and, in case the network is receiving public funding, the innovation policies. An intention and motivation towards the interfirm KT are needed from all mentioned parties to successfully carry out projects that have effective and beneficial KT. However, the mere existence of motivation and intention may not be enough since due to the complexity of the network dynamics, the facilitation of collaboration can sometimes require a laborious analysis of the network conditions and capabilities of individual members (e.g., identification of the root cause for insufficient interfirm KT). The real question may not be whether the interfirm KT in R&D project networks is desirable, but how desirable it is.

## 5.2 Implications for R&D project management and innovation policies

The premise of these implications is that interfirm KT in the R&D project context is a desirable objective. The results suggest that interfirm KT is significantly hindered by the lack of motivation the firms have towards the knowledge of other network members, especially concerning knowledge related to the R&D results produced during the project. However, on occasions of trying to achieve mutual business objectives, the collaboration was active.

These findings lead to two basic solutions on how interfirm collaboration could be facilitated. First, choosing firms with highly similar R&D goals as the consortium would mean the R&D results of individual network members would have wider relevance in the network. A similarity of goals would also enable the coordination and sharing of the R&D activities on the project level, which would reduce the

resourcing needs of individual network members. This would increase the clarity of roles in the projects, which, according to the findings, supports KT.

Second, interfirm KT could be facilitated by having firms with synergic business objectives enter consortiums. However, this objective would likely be difficult to achieve simultaneously with highly scoped and similar R&D goals; thus, two separate project models would be required to exploit the offered solutions.

Both solutions are highly related to the resources and capabilities of the actors who are responsible for the consortium building. The identification of potential consortium members with highly scoped and similar R&D goals is a more resource-related challenge<sup>1</sup> because suitable members would have to be identified from a larger group of companies than in the current model which allows wider R&D scopes for projects. If the emphasis is on building consortiums with members having synergic business objectives, an understanding of business models and opportunities is required. This can be challenging because typically, researchers have central roles in project planning and their main orientation is in R&D.

In addition, the motivation towards new knowledge and commitment towards learning can be hindered by the unclarity of strategic (R&D) goals in companies. Especially in case of SMEs, the companies' strategic goals and R&D intentions can be blurry, which may hinder the understanding on the potential of learning from other project network members. This in turn can result as insufficient qualitative and quantitative resourcing of the collaborative activities. Quite often the companies would benefit from external support for clarifying the R&D objectives. Perhaps this kind of service should be offered systematically by public actors as a preceding phase before the actual project planning. Creating appropriate visibility on companies R&D intentions would also greatly benefit the coordinators of project planning, as they would be able to directly contact companies with, at least to some degree, interest towards the topic of the planned project.<sup>2</sup>

Although social capital was not a so-called primary affecter of interfirm KT, it was still a facilitator of KT in several cases. An awareness of the significance of social capital to KT and monitoring the development of social capital during the project execution would allow project coordination to take actions to support the formation

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<sup>1</sup> Since the interviews were conducted for this study (2015–2017), there has been renewal in central Finnish R&D funding instruments. The largest public funder for research, development and innovation in Finland—Business Finland,—currently offers specific funding (co-creation) for consortium building and planning the actual R&D project.

<sup>2</sup> Since the interviews were conducted for this study (2015–2017), Business Finland has launched a Veturi-programme in which some of the Finnish leading companies and their ecosystems have created public R&D roadmaps. These roadmaps act as a supporting framework for project planning.

of social capital, for example, activities that involve and motivate several consortium members. Also, not all activities have to be for every member of the consortium. The so-called core groups formed in two of the studied cases, in which social capital developed quickly. Identification of these potential members for a core group could also be a recommendable activity for project coordination. Naturally, a basic requirement for the successful facilitation of interfirm KT is that it is internalised as one of the objectives of coordination. To what extent this is the case is uncertain.

The firms shared their R&D results openly, mainly during the coordinated project meetings, which were held regularly. Although, according to the results, there was dialogue in these meetings, there might still be the potential to deepen the discussions. Instead of emphasising the reporting aspects, the meetings could have had a more workshop-type orientation, including joint problem solving, that would lead to joint knowledge creation.

Finally, as somewhat wider theme, the author suggests questioning the premise of strict project orientation in the public R&D funding. Naturally, the project model funding creates efficiency and easiness for many aspects of governance, but at the same time it causes great discontinuities for competence cumulation and collaboration. Not to mention the costs created by the repeated applying processes. Perhaps, at least partly, the funding could be organized more strategically through platforms or coordinated ecosystems, whose performance, memberships, and funding continuation would be regularly evaluated. For the creation of social capital this would create favorable conditions as the network would not be designed for being temporary at the first place, which in turn would likely increase the motivation towards developing more refined collaboration practices. Other possibility to tackle the challenges related to the temporary nature of project networks, could be arranging flexible public funding opportunities for successful project consortiums to continue their work after the original project deadlines.

### 5.3 Limitations and recommendation for future research

The theoretical implications presented are outcomes of qualitative methods. Although the findings are valid in the real-life context, any generalisation would require quantitative testing. In addition to the context of the current study, the testing could take place in other network types and/or by including research organisations and universities in the study context. In addition, perspectives from other

countries/regions with dissimilar business ecosystems and societies would assist in evaluating the generalisability of the results.

The concept of social capability was chosen as the theoretical approach to identify and structure the findings concerning the facilitation of KT. There were two main reasons for this. First, the width of the concept allowed for structuring a wide variety of the findings. Second, social capital has successfully been used for similar purposes in previous research. However, focusing on, for example, one of three dimensions of social capital would allow for an even more detailed analysis. Another potentially interesting option would be a longitudinal study to deepen the understanding of the development and accumulation of social capital.

Besides social capital, other suitable theoretical approaches could be used to deepen the understanding of interfirm collaboration in R&D project networks. An evaluation of the significance and impacts of formal and relational governance would give valuable insights into the topic (for formal and relational governance, see Poppo and Zenger, 2002). Considering the focus of the current dissertation, this would be especially interesting because some social capital features, such as norms and trust, are considered to be the mechanisms of relational governance. Because little attention was given to the characteristics of individual firms in the current study, an analysis based on firm-level features, for example, through absorptive capability (see, e.g., Cohen and Levinthal, 1990), is recommended. On the other hand, a wider approach could be chosen to capture the required capabilities for planning and execution phases of the project (e.g. in Hietajärvi et al., 2016). In addition, for studying the effects of network diversity on KT, the technological and cognitive distances (see, e.g., Nooteboom et al., 2007) could be evaluated.

## 6 CONCLUSIONS

The broad goal of the research presented in the thesis, was to deepen understanding on interfirm collaboration in the context of R&D research projects supported by public funding. During the research, the aim was narrowed on identification of network conditions in R&D project that effect the interfirm KT, especially the significance of social capital to KT was investigated. The focus was considered justified, as R&D project networks have unique features compared to other, more studied, network types and thus the previous research may not be capable of explaining sufficiently the dynamics of R&D project networks. This premise was also supported by a study, presented in the thesis, in which social capital characteristics between strategic alliances and R&D project networks were compared. The results emphasized the uniqueness of R&D project networks as network type.

During the early stages of the research, it became evident, that vast range of capabilities is needed for successful interfirm R&D collaboration. However, as the knowledge can be considered as a cornerstone of the collaboration, also the capabilities related transferring, sharing, and applying knowledge are of high importance. Thus, the micro-foundations of dynamic capabilities and organizational learning were found to be well suited for explaining preferable conditions and capabilities for R&D collaboration between firms.

Overall, the direct interfirm collaboration and KT in studied projects was relatively low, especially when compared to the collaboration between firms and universities or research institutes. Still, when the interfirm collaboration existed, it resulted several benefits for firms such as getting feedback for own R&D activities and deeper customer-supplier understanding. Interestingly, learning between firms within the R&D scope of the project was not reported.

The dynamics of interfirm KT were found to be complex. In the present study the favourable conditions for interfirm KT were considered to result from combinations of facilitative conditions and absence of factors limiting the KT. The changes in project consortium, in project budgets, in project length, and budget were found to limit the KT. Also, although the projects had shared project plans, the firms considered differences of R&D intentions to limit the KT. Furthermore, in some

occasions the deep collaboration with universities and research institutes satisfied the learning related needs and thus the interfirm collaboration was not considered necessary. However, social capital related factors, merely absence of social capital, were not recognized to hinder the KT.

The effects of structural, relational, and cognitive dimensions of social capital on KT were studied in detail. The results suggest that the presence of social capital does facilitate the interfirm KT, but it needs to be accompanied by shared business intentions in order to obtain the most beneficial outcomes. However, none of the dimensions can be considered being more important than the others in order to have active KT between firms. This highlights the interconnectedness of social capital dimensions. In addition, two other noteworthy observations were made during the research. First, with right type of activities in the early stages of the project the social capital can develop fast. When this is considered together with the observation on the facilitative effects of social capital, it can be concluded that building social capital in contemporary networks, such as studied in the thesis, is valuable activity. Second, the study shows, that sharing the R&D knowledge openly is far from enough for the knowledge to be transferred from a firm to another.

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# PUBLICATIONS



# PUBLICATION 1

## **Collaborative Innovation Capabilities of SME Network**

M. Majuri, R-J Halme, M-J Kopra, H. Nylund

In: Proceedings of the 25th International Conference on Flexible Automation and Intelligent Manufacturing: designing for advanced, high value manufacturing and intelligent systems for the 21st century, FAIM 2015, 2(175), 404-409.

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# Collaborative Innovation Capabilities of SME Network

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## ABSTRACT

*This goal of this research is to identify capabilities supporting collaborative innovation of manufacturing processes. The focus is on small and medium-sized enterprises (SMEs) in Finnish mechanical engineering industry, i.e. discrete part manufacturing for business-to-business (B2B) industry. For a single SME, the renewing of a business model can be challenging due to lack of resources, risk tolerance and right kind of know-how and skills. Collaboration and co-creation of SMEs that aim for new innovative offering, processes, or business models, is a potential solution to tackle these challenges. Being successful in this collaboration and co-creation requires capabilities that should be recognized and systematically improved. For recognizing the capabilities, two viewpoints, steps of manufacturing process innovation and innovation capability categories are discussed. The main result of the paper is that these two viewpoints are synthesized to find out the importance of the capability categories in each step of the manufacturing process innovation. The research methods for achieving the results presented in this paper were a combination of analysing the results of a previously conducted research project and reviewing relevant literature related to the goal of the research. These we carried out individually by several researchers and at workshops to collect the ideas in to a common understanding.*

## 1. INTRODUCTION

To be successful in current fast changing global business environment, companies have to be able to renew themselves in short cycles. Although renewal through incremental and systematic development is still valuable, in many situations a more innovative and radical approach is needed to differ from the competitors, create competitive advantage or even to open up completely new market space. The target of innovation can be in renewing the offering, processes and/or the whole business model. In companies located in high-wage countries, the role of innovation capability is especially significant, because in those countries companies have to be able to cover the high total cost by creating more customer value than their competitors in low-wage countries. Yet, the cost effectiveness is something that cannot be left out of the scope. Even in the high customer value products the costs matter. Process innovations, e.g. in manufacturing, can have a decisive impact on whether the product becomes a commercial success or not. Naturally the manufacturing is in significant role also in achieving the desired quality levels and delivery performance.

For small and medium-sized enterprises (SMEs) the pressure for renewal can be even higher than for large companies. Especially manufacturing oriented sub-contractors without own products are often in situation, where their customers are moving their supply chains to low-cost countries to have better access to fast growing markets or to cut down the costs. On the other hand the brand owners expect their suppliers to be able to deliver larger entities and understand the needs of the end customer to be able to support brand owners' ability to create higher customer value. These trends have led many SMEs to consider new business models and also raised the interest towards innovation.

Especially sub-contractors have traditionally been renewing their processes and business models incrementally and independently. When company aims for more radical improvements through innovation it faces a new situation with a need for new kind of capabilities and risk management. Innovation itself may also require wide variety of skills and capabilities which can be out of the reach for a single company. For these situations the collaboration with other companies may be the solution. Collaboration allows risk sharing and brings new skills to innovation process. On the other hand, an efficient collaborative innovation process requires capabilities which support the co-operation between the companies and enable transformation of ideas into commercial products or processes.

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This paper focuses on identifying the capabilities that support collaborative innovation in SME networks. To emphasize the systematic nature of innovation process, an example of manufacturing innovation process is presented. Additionally, capability groups for collaborative innovation have been formed and their importance at each step of the innovation process is presented. This allows more systematic development and management of the collaborative innovation process. Also a definition 'Time to Innovation' is introduced to better evaluate the efficiency of the innovation process.

## 2. BACKGROUND

A recently developed method for modelling strategic capabilities of SME in a wide scale was exploited to recognize the collaborative innovation capabilities and to form the capability groups presented in this paper. The method, which is called Strategic Capability Index (SKI), is based on over 200 capabilities which were identified in close co-operation with seven SMEs and several experts from academia and different institutions. Data for the SKI method is collected by having over 600 best practice-based statements' accuracy evaluated in individual companies. SKI method has been piloted in seven companies and the feedback has been positive. Following topics form the main capability categories of the method: 1. Human resources, 2. Leadership and management, 3. Marketing and sales, 4. Renewal and development, 5. Production, 6. Networking and partnerships, 7. Internationalization.

The research presented in this paper is part of the work done in ongoing research project called *Renaissance of the Regions – Challenging the Status Quo of Innovation Policy Implementation in Regional Manufacturing Networks (ReRe)*. Project goal is to create improved methods and means for public sector to support and develop innovation process in SME networks. For this purpose the identification of innovation capabilities in different phases of collaborative innovation process is necessary. The identification started with analysing the strategic capabilities of the SKI method from the viewpoint of networked collaboration. The analysis was carried out in several workshops narrowing down the capabilities that were relevant for the study taken into consideration of the goals of the ReRe-project. The attendees of the workshops were prepared by performing individual reviewing of previously conducted research in the field. The results of the workshops were divided into two dimensions. The first dimension includes the steps in the collaborative innovation process while the second dimension consists of several categories of collaborative innovation capabilities. These were combined into the main result of this paper i.e. what are the most important capabilities for successfully realising the steps of the collaborative innovation process. This knowledge allows public sector to target their supportive activities into right phases of the innovation process and also support the improvement of the relevant capabilities. By these activities the public actors are able to fasten the innovation process. On the other hand the results can be exploited by the companies to deepen the understanding on the collaborative innovation process.

## 3. COLLABORATIVE INNOVATION

In the ongoing research project, three different kinds of innovation processes have been identified supporting the goals of the research project. The first two processes focus on product innovations. The third one, which is presented in this paper, discusses on innovations of the manufacturing processes. Generally, process innovation is the implementation of a new or significantly improved production or delivery method [1].

In the following, the steps of the collaborative innovation process are presented. Secondly, the capabilities of the SKI methods that are most important for the innovation process are divided into several capability categories. These two viewpoints are then combined and the importance of each capability category is discussed related to the steps of the process innovation.

### 3.1. STEPS IN COLLABORATIVE INNOVATION

Figure 1 illustrates the overall view of the steps in the manufacturing process innovation. In early phases the focus is on management of ideas and on decreasing the amount of ideas. Further steps focus on change management and on implementation of the chosen idea(s).

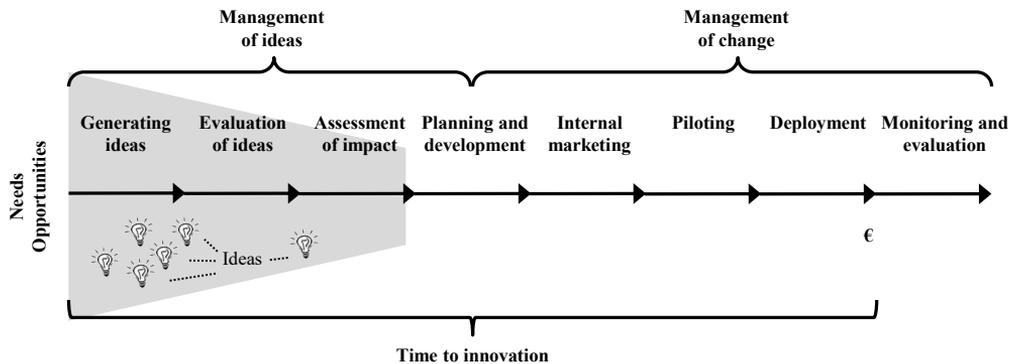


Figure 1. Steps in collaborative innovation.

The first step, **generating ideas**, starts with identifying new opportunities or needs for change in the manufacturing process. These will bring out new requirements and if they cannot be fulfilled with the existing capabilities of the manufacturing network, new ideas are required to progress further. On the other hand, a new idea can arise without prior knowledge of any requirements and it can be seen as a promising solution. At the end of this step, the amount of ideas can be quite large. An important part in **evaluation of ideas** is to rapidly understand which ideas are not applicable and to narrow down ideas that have potential for success. Then, residual ideas will be further evaluated. Typical topics in idea evaluation phase are considering the benefits and disadvantages of a certain idea in short and long terms as well as how it may change the way of working in the collaboration network. At the end of this step, one idea will be selected to be developed further. The next step is the **assessment of the companies that will be impacted** by the selected idea. This is a specific step that emerges when the innovation process concerns collaborative network rather than an individual company. The companies to be impacted must be recognized and they must be communicated the change to make sure they will have full understanding of the changes and will be participating in the innovation process.

During the step of **planning and development**, management of ideas turns into management of change. Similarly, the idea will change into more concrete topic having objectives. The objectives define the expected output, which in turn define the steps to achieve the desired output. The result should be a clear development plan that can be executed and doesn't miss any important aspects. **Internal marketing** is an important step to progress further as the involved companies must be motivated and willing to continue the innovation process. In this step, the benefits and challenges must be clearly reported as well as how much and what kind of resources a company must allocate in a specific time period. For the **piloting** step, some units from the collaboration network are chosen to implement the new way of working i.e. changing the way they are doing business. During the step of piloting, the new way of doing business is implemented, data is collected and analysed from the piloting process, and corrective actions are taken where the planned and actual results differ from each other.

The **deployment** step can start when the results from the piloting are satisfactory i.e. meeting the requirements, which were set earlier in the innovation process. The goal is that all involved companies in the collaboration network have their processes aligned with the new way of doing business. The steps of the process alignment should be clearly described in that the involved companies can rapidly adapt their process to the new situation. At the end of the steps in the collaborative innovation process, after the deployment, the new way of working will become normal way of doing business. At that point the innovation process will be changed into improvement process. In the improvement process the normal way of working is **monitored and evaluated** to define continuous and incremental improvement steps. The improvement differs from an innovation in that the application of the new idea is changed from generating something different into improving the current process focusing at e.g. reducing cost or delivery time.

### 3.2. CAPABILITIES IN COLLABORATIVE INNOVATION

The authors analysed the strategic capabilities, defined in SKI project (presented in Chapter 2), from the collaborative innovation point of view, and agreed that many of the defined capabilities were relevant for the study. However, the main categories of the capabilities were somewhat irrelevant in this new context. Also, additional

capabilities, supporting the collaborative innovation, were identified in a researchers' workshop. The authors divided the selected collaborative innovation capabilities into seven categories:

- Interaction and knowledge sharing
- Information acquisition and refining
- Management and leadership
- Values and principles
- Technology
- Processes and practices
- Know-how and skills

**Interaction and knowledge sharing** refers to capabilities which define how the SME network members (individuals, teams/projects and companies) are able to interact and share their knowledge. It is recognized, that the most effective way for to transfer knowledge, is to let people talk to one another [2]. Motivation for sharing knowledge is based on the considerations of personal benefit, community related expectations and normative beliefs [3]. Capabilities in the group of interaction and knowledge sharing include e.g. creating and maintaining personal relationships (also non-work related activities), open and honest communication within the network, information and knowledge sharing both on personal level and via ICT systems, joint understanding of the rules in the network, as well as, altruistic and sincere willingness to help other members in the network. Innovation is predicted based on the ability to integrate new information with existing knowledge, to create something new [4].

Capabilities in the category of **information acquisition and refining** describe how the SME manufacturing network acquires information from various sources, both internal and external and refines it into explicit and tacit knowledge for further use. These capabilities include e.g. systematic monitoring of business environment and performance in the network, information acquisition for problem solving and systematic documentation.

**Management and leadership** category includes the capabilities which needed to control the resources, as well as, to set a vision for the network to follow. According to Ueki et al. [5], strive for improving the brand value and the customer satisfaction, improves the effectiveness of the knowledge creation process. Examples for the capabilities in this group are positive and inspiring leadership and strategic planning. Also, organizational design is included in this capability group because the organizational structure can impede conversations, which could develop valuable knowledge [6].

Capabilities in the **values and principles** category describe the norms, rules and values which are desired in the SME network. Most people have a natural desire to make things better, but this natural desire is thwarted by a variety of logistical, structural and cultural hurdles that the organizations create [7]. For example, effective leverage of knowledge requires commitment of the top leadership and role models, who exhibit the desired behaviour [8]. Values and principles related capabilities include e.g. willingness to take risks, approach to failure, resourcing based on competences and interests, justifying development projects with business goals, management of change and commitment to the organization or network.

**Technology** refers to the machines and tools used in the manufacturing processes of the companies in the network. Capabilities in this category include e.g. diverse technological know-how, flexibility and scalability in production, purposeful manufacturing automation (quantity and quality) as well as maintenance and development of the manufacturing technology. Another important technological viewpoint is information and communications technology (ICT), which aids in information and knowledge management and offers tools for virtual design and development.

**Processes and practices** define how the SME manufacturing network operates. Capabilities, like flexible processes and resourcing for ad hoc cross-functional task forces to solve urgent problems, training multi-talent resources, agile process development and change management (product and production documents), are considered important for collaborative innovation. From the innovation point of view, the work processes need to allow people to have time to generate and share knowledge and, then, also identify those who may be interested in sharing their knowledge [7].

**Know-how and skills** refers to the acquired knowledge or ability to carry out activities in the SME network. These capabilities include e.g. understanding of production material flow, convincing track record in operational changes, legal and contractual competences, as well as, understanding the whole supply chain are important in collaborative innovation in manufacturing networks.

### 3.3. IMPORTANCE OF THE CAPABILITIES IN THE INNOVATION PROCESS

All of the capability groups are integral in the process innovation. Some of the capability groups have an important role throughout the process and some of the categories are important only in some steps in the process. The most critical capability groups are highlighted in the Table 1 and discussed later in this chapter.

Each capability category is constituent of the innovation process and the authors highlighted one capability group as the most critical capability groups in each process step. However, it should be noted that the capability groups without an entry, may be relevant, but they do not usually have a significant impact on the success in a specific innovation process step. Our hypothesis for the importance of the capability categories in the innovation process is presented in Table 1.

Table 1. The importance of the capability categories in the innovation process.

<i>Process steps</i>	Generating ideas	Evaluation of ideas	Assessment of impact	Planning and development	Internal marketing	Piloting	Deployment	Monitoring and evaluation
<i>Capability categories</i>								
<b>Interaction and knowledge sharing</b>	x	xx	<b>XX</b>	x	xx	x	<b>XX</b>	
<b>Information acquisition and refining</b>	<b>XX</b>	x	x	xx		xx		<b>XX</b>
<b>Management and leadership</b>	x	xx	xx	x	xx	x	x	x
<b>Values and principles</b>	xx	x		xx	<b>XX</b>	x	x	x
<b>Technology</b>		x		xx		xx	xx	x
<b>Processes and practices</b>	x	xx	x	<b>XX</b>	x	x	xx	x
<b>Know-how and skills</b>	x	<b>XX</b>	x	x	xx	<b>XX</b>	x	

Legend **XX** the most critical capability group in a certain innovation process step  
 xx capability groups with high importance  
 x important capability groups

When generating ideas for the innovation, the most critical capabilities are related to the category of information acquisition and refining. The members in the SME manufacturing network need to acquire and analyse information from various sources to identify the new opportunities or the needs for the change initiating the innovation process. Evaluation of ideas to understand which ideas are applicable and which are not, requires a lot of knowledge about the manufacturing process. Therefore, the capability group of know-how and skills is the most critical in this step of the innovation process. The role of interaction and knowledge sharing capabilities is emphasized in the step of assessment of impact. It is vital for the SME manufacturing network to understand the impact of the suggested idea to all the members in the network, before the process change is implemented in the production process.

In the planning and development step, the most critical capability category is processes and practices. In this step, the idea is expressed as concrete objectives and a plan describing the way to reach the objectives, is created. Processes and practices describe the steps to achieve the desired output. The purpose of the internal marketing is to increase the motivation and willingness the members of the SME network to implement the planned change in the manufacturing process. In this step, the most critical capability group is values and principles.

When the piloting of the new manufacturing process starts, the importance of the know-how and skills related capabilities significantly increases again. Successful deployment of the change in the manufacturing process requires seamless co-operation within the SME manufacturing network. Therefore, the capability of interaction and knowledge sharing is highlighted as the most critical capability group at this phase. In the monitoring and evaluation step, the SME manufacturing network analyses the impact of the process innovation. Consequently, the capability category of information acquisition and refining is considered to be the most critical.

As seen in the Table 1, two capability categories, management and leadership, as well as, technology, were not highlighted as the most critical capability category in any step of the innovation process. Leadership related capabilities are essential at the beginning the of the innovation process to lead the people, as well as, to create an appropriate atmosphere in the SME manufacturing network, to ensure that the innovation process can progress smoothly. Later in the process, the management and controlling the resources is more important. The role of the technology related

capabilities increases when approaching the deployment step in the innovation process. However, the SME companies' readiness to use technology in the innovation process varies greatly. For example, simulation models could be very useful when designing a change to the manufacturing process but the simulation tools are not used in a large scale.

#### 4. DISCUSSION AND FUTURE WORK

In this paper, we present a hypothetical model that could be used for recognizing the phases of collaborative innovation process in SME network in manufacturing development, and to understand the variety of capabilities needed in the different phases of innovation process. In general, the model gives the SME network a deeper understanding of its innovation capability.

In the innovation process, the source of ideas may vary greatly and the process of idea creation is often rather abstract. However, the process of taking ideas into action is more systematic. We want emphasize the systematic nature of the innovation process, and also to give structure for systematic development of the capabilities needed in the innovation process.

All phases of the innovation process require multiple capabilities, although in different phases of the innovation process individual capabilities have bigger roles. This information can be used for prioritizing the development work after the bottlenecks of innovation phases have been recognized. On the other hand, the development of the capabilities requires long-term commitment and leadership commitment, especially in the area of network's values and principles which form the basis for collaborative innovation. Although technology is often in the focus of the manufacturing innovations, the successful innovation process with short *Time to Innovation*, is more about people and their ability to interact across the organizational and functional borders.

The model is still preliminary and the usability or usefulness has not yet been tested in the context of collaborative innovation. However, we want to expose the model to scientific discussion already at this point, and request feedback for our ideas. The coming research activities will include several possibilities to implement, evaluate and further develop the model, e.g. workshops, interviews and pilots in the manufacturing SMEs and their networks, as well as, with the national actors supporting the innovation process. Also, the theoretical evidence supporting the identified capabilities and their importance in the innovation process, needs to be strengthened.

#### ACKNOWLEDGEMENTS

The research presented in this paper is co-financed by Tekes, the Finnish Funding Agency for Technology and Innovation, and Tredea Oy, the Tampere Region Economic Development Agency. We want to thank researcher Jari Laine from Aalto University for his support during of these first steps of the research.

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# PUBLICATION 2

## **Capability Building Through Dynamic Capabilities and Organizational Learning**

Majuri, M., Halonen. N.

In: Leal Filho W., Azul A., Brandli L., Özuyar P., Parede T. (eds) 2020. Responsible Consumption and Production, Encyclopedia of the UN Sustainable Development Goals, 49-59.  
doi: [https://doi.org/10.1007/978-3-319-71062-4\\_2-1](https://doi.org/10.1007/978-3-319-71062-4_2-1)

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# C

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## Capability Building Through Dynamic Capabilities and Organizational Learning

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### Definitions

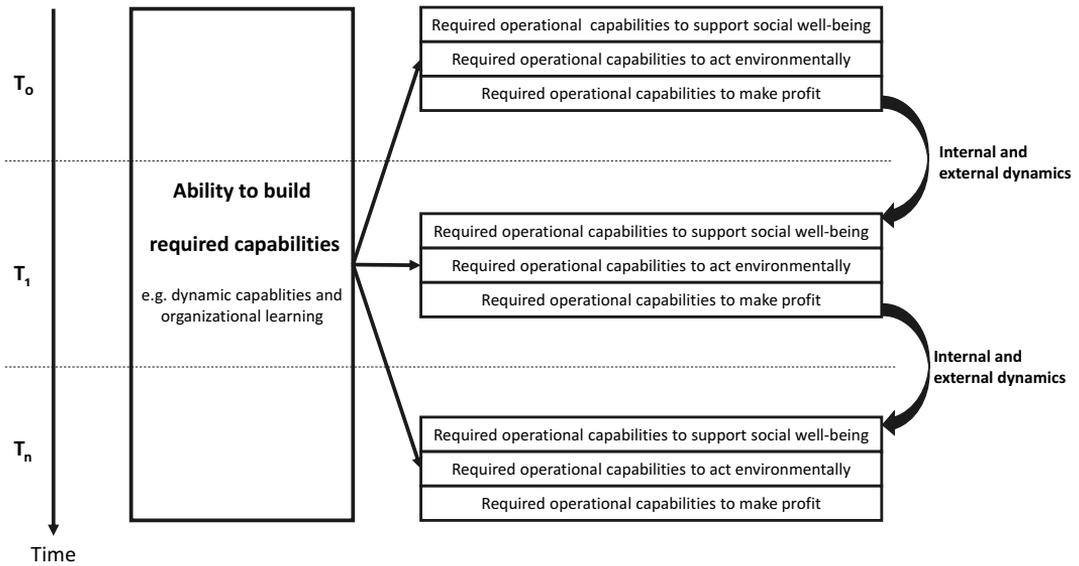
Depending on the field of research, capability has various meanings. In this entry, capability is defined as organization's ability to achieve specific goals. Capabilities form from combinations of skills, knowledge, technology, routines, and organizational culture. Capability building means renewal of organization's capability base by developing, remodifying, and even eliminating individual capabilities.

### Introduction

As the world changes on a fast pace, firms need to develop new capabilities, not just to cope with the changes but also to prosper in the changing business circumstances. Yet, also sustainability sets new requirements for firms to look beyond the present moment or short-term development. Sustainability theory offers simple and practical framework to approach the subject. Sustainability is typically considered to have three dimensions

through which sustainability can be evaluated: social, environmental, and economic. Changes occur in all dimensions and may have direct or indirect influence on firms' business. Direct influence means that changes occur in the value chain of a firm, e.g., in supplier performance or customer behavior. In case of indirect influence, the change happens originally outside of the immediate business environment, but it still reflects to the value chain, e.g., raw material prizes affect the business of customer's customer. Quite often the indirect change force is difficult to sense causing firms react too late. The changes may be also internal, e.g., aging of the firm's personnel, or external, e.g., global warming. What makes these changes especially challenging for firms is that they are often fast and large, e.g., collapse of Soviet Union in 1991, and hard to predict, e.g., financial crisis in 2008. In addition, the markets themselves are in the global economy dynamic or even volatile, and market windows are smaller and open less time than ever before. This means that firms need constantly new operational capabilities to meet the present requirements of their business environments.

Figure 1 illustrates how changes in social, environmental, and economic dimensions influence the requirements toward firm's operational capabilities in a certain moment of time. Operational capabilities are the explicit routines and actions that define firm's current performance and competitiveness in relation to other firms in the market. Ability to build, and sometimes



**Capability Building Through Dynamic Capabilities and Organizational Learning, Fig. 1** Capability building framework

get rid of certain operational capabilities, is crucial for sustainable competitiveness (Fig. 1, ability to build required capabilities). Operational capabilities are used in day-to-day business, and their business value may diminish or strengthen along with changes in the business environment. Instead, the enablers of building operational capabilities are often more sustainable by their nature and, compared to operational capabilities, will benefit firms in a larger variety of business scenarios. It should also be noted that not all operational capabilities are used all the time. Some operational capabilities can be considered to be in the reserve of the firm forming the operational flexibility. This means that they are immediately or almost immediately available if needed as circumstances change.

To explain firm's ability to build capabilities, two theories were chosen: dynamic capabilities (DC) and organizational learning (OL). There are three reasons for addressing the topic through these particular theories. First, they both have been central research topics for over 20 years. Thus, they are relatively well-established. Second, capability building is a wide theme. Choosing two theoretical lenses instead of one

gives a wider perspective for the topic. Third, both theories are versatile by their nature and so suitable for explaining capability building.

Both theories, DC and OL, are discussed in their own sections. Sections begin with a definition(s) of the theory. Then the connection to capability building is explained. This is followed by short descriptions of the theory. Last parts of the sections focus on the microfoundations of the theories to give pragmatic overview on what are the enablers of DC and OL. Although DC and OL have several meeting points and somewhat same function from firm's point of view, they also have some differences. These similarities and differences are discussed in the final section of this entry. The goal is not to comprehensively cover all the enablers of capability building but to give reader introduction to a variety of capability building enablers that support firm's sustainable competitive advantage.

## Dynamic Capabilities

Helfat et al. (2007) defined DC as organization's capacity to purposefully create, extend, or modify

its resource base. This means that DC are capabilities that enable organization to adapt to the changes in its business environment or even create market change (e.g., Eisenhardt and Martin 2000; Teece 2007). According to Teece (2007), DC explain how a firm may achieve sustainable competitive advantage in ever-changing business environment. From a single firm's point of view, this implies that in sustainability context DC support foremost the economic sustainability. However, social and environmental changes quite often have a direct and/or indirect impact on firm's business environment. This means that to sustain the competitive advantage, firms need to actively sense changes in all dimensions of sustainability and renew their operational capabilities accordingly. In this sense, DC can be considered a source of sustainability, not only in the economic sense but also from social and environmental perspectives.

### Connection to Capability Building

As the term *dynamic capabilities* implies, DC are also a type of capability. However, the structure of organizational capabilities can be considered as hierarchical (Winter 2003). The ones used to meet the requirements of the present moment are operational capabilities or as Winter (2003) called them "zero-level" capabilities. Unlike operational capabilities used for daily actions, DC lie deeper in the organizations. When operational capabilities explain the success in the present moment, the DC explain success on more sustainable basis. DC can be described as a capability building capabilities. However, the distinction between operational and DC is somewhat blurry, e.g., same capability in some occasions may fit into both categories (Helfat and Winter 2011).

As the requirements toward operational capabilities change along with the changes in the business environment, the DC can remain unchanged for relatively long periods of time as they offer competitive advantage for a firm in different business circumstances, e.g., ability to sense business environment and react to changes. Still, also DC can and should change over time or even decay (Easterby-Smith et al. 2009). Viewing DC critically and taking developing actions when

needed is necessary. However, this can be sometimes difficult, since the existing DC may have a long history as a source of competitive advantage in the firm and thus have a strong support from personnel and management.

### Evolution of the Theory

DC were brought into the spotlight of the research community in 1997 by seminal paper *Dynamic Capabilities and Strategic Management* by Teece, Pisano, and Shuen. The study of DC started as an approach more than a theory (Helfat and Peteraf 2009), but it has since developed into a one of the most studied subjects in business, strategy, and management research.

As the nature of DC theory is interdisciplinary, it consists of elements from several areas of research, e.g., from management of R&D, product and process development, technology transfer, OL, and human resources. Still, probably most commonly it is associated with research-based view (RBW). Similarly as DC, RBW aims to explain sources of firm's sustainable competitive advantage (e.g., Kraaijenbrink et al. 2010; Easterby-Smith et al. 2009).

### Microfoundations of Dynamic Capabilities

DC seeks to understand wide and complex subject, the source of sustainable competitive advantage. At the same time, as a theory, it is still relatively young. Therefore, it is not surprising that the theory of DC has received also critique from the science community. Arend and Bromiley (2009) argued that theory of DC lacks clarity concerning practical implications and weak empirical support. There is also debate on the relevance and accuracy concerning capability research in general (e.g., Felin and Foss 2010). However, several studies naming and characterizing DC are, at least on some degree, answering these challenges.

In his article *Explicating Dynamic Capabilities: The Nature and Microfoundations of (Sustainable) Enterprise Performance*, Teece (2007) structured DC into three classes: (1) capacity to sense and shape opportunities and threats, (2) capacity to seize opportunities, and (3) capacity to manage threats and transforming. Further in the

**Capability Building Through Dynamic Capabilities and Organizational Learning, Table 1** DC as enablers of sustainable competitive advantage (Teece 2007)

Enablers of dynamic capability	Description and foundations
Capacity to sense and shape opportunities and threats	Processes to direct internal R&D and select new technologies Processes to tap supplier and complementor innovation Processes to tap developments in exogenous science and technology Processes to identify target market segments, changing customer needs, and customer innovation
Capacity to seize opportunities	Delineating the customer solution and the business model Selecting decision-making protocols Selecting enterprise boundaries to manage complements and “control” platforms Building loyalty and commitment
Capacity to maintain competitiveness through enhancing, combining, protecting, and reconfiguring tangible and intangible assets	Decentralization and near decomposability, e.g., embracing open innovation Governance, e.g., achieving incentive alignment Cospecialization: managing strategic fit so that asset combinations are value enhancing Knowledge management, e.g., knowledge transfer and learning

article, he presented selected microfoundations enabling these DC. While his intention was not to aim for a conclusive description of the microfoundations, the selected DC enablers reflect and answer well to the requirements of modern day business environment.

Authors of this entry have summarized and described enablers of DC on Tables 1, 2, 3, and 4. The purpose of the tables is not give a comprehensive list of the enablers of DC, but to present the wide variety of DC and also show that the theory of DC can be approached from different points of view. Table 1 presents enablers of DC identified in Teece’s (2007) article: *Explicating Dynamic Capabilities: The Nature and Microfoundations of (Sustainable) Enterprise Performance*.

Table 2 presents four types of capabilities that support the formation of DC in the context of new product development in a turbulent environment. The table was summarized from article *Understanding the Elusive Black Box of Dynamic Capabilities* by Pavlou and El Sawy (2011).

In their paper *Microfoundations of Routines and Capabilities: Individuals, Processes, and Structure*, Felin et al. (2012) consider capabilities to form a hierarchical structure in which DC are higher-level capabilities that support building capabilities at lower levels. At zero level are

**Capability Building Through Dynamic Capabilities and Organizational Learning, Table 2** DC in the context of new product development in turbulent environment (Pavlou and El Sawy 2011)

Enablers of dynamic capability	Description and foundations
Sensing capability	The ability to spot, interpret, and pursue opportunities in the environment
Learning capability	The ability to revamp existing operational capabilities with new knowledge
Integrating capability	The ability to embed new knowledge into the new operational capabilities by creating a shared understanding and collective sense-making
Coordinating capability	The ability to orchestrate and deploy tasks, resources, and activities in the new operational capabilities

the operational capabilities that are used in day-to-day business. Table 3 lists and describes the building blocks of these capabilities.

Helfat et al. (2007) approach the subject of DC formation from acquisition, management, and alliance perspectives. Their findings in the book *Dynamic Capabilities: Understanding Strategic Change in Organizations* are summarized in Table 4.

**Capability Building Through Dynamic Capabilities and Organizational Learning, Table 3** The building blocks of DC (Felin et al. 2012)

Enablers of dynamic capability	Description and foundations
Individuals	Human capital, e.g., skills, knowledge, and cognitive capacities Choices that individuals make – affected, e.g., by individual beliefs, goals, and interests
Processes and interaction	Processes are a series of independent events and need an individual intervention to be put into action Interactions between individuals, processes, technology, and ecology are coordinated with formal and informal governance
Structure	Design of decision-making activities, e.g., decision-making rules Organizational structure, e.g., complexity of the structure Firm’s founder’s logic effects, e.g., level of the bureaucracy in the firm

Although the presented descriptions of micro-foundations have different emphasis, some similarities are obvious. All authors underline the role of management and managerial processes in rooting the renewal. Also, the ability of sensing the environment and processing the new knowledge are common features between all sources.

Naturally, like all other well-studied theories, also DC has received critique. However, the critique concerns mostly DC as a theoretical framework, not so much the factors included in the DC. Evaluation of this critique is beyond the scope of this encyclopedia entry as the main goal is to enlighten the topic of capability building for which the theory of DC suites well.

**Organizational Learning**

OL is a form of organizational capability to process knowledge, including the creation, acquisition, transfer, and integration of knowledge and modification of organization behavior in

**Capability Building Through Dynamic Capabilities and Organizational Learning, Table 4** DC from management, acquisition, and alliance perspectives (Helfat et al. 2007)

Enablers of dynamic capability	Description and foundations
Managerial capabilities	Asset orchestration: frequently involving co-specialized and complementary assets within the resource base of an organization Design of appropriate asset governance and incentive structures
Senior executive behavior and actions	Ability to critically evaluate present DC, develop new ones, and let go, if necessary, the old ones.
Relational capabilities	Relation specific assets Complementary capabilities Interfirm knowledge-sharing routines Effective governance
Acquisition-based DC	Acquisition selection ability – assess existing resource gap and the degree of market failures related to existing resources Acquisition identification ability – capacity to detect and negotiate with appropriate targets Acquisition reconfiguration ability – capacity to reshape resources within the target and acquiring firm

order to reflect a new cognitive situation and improve organization performance (Jerez-Gomez et al. 2005). It consists of both individual-level and organizational-level learning aspects, latter known as collective learning (Huber 1991). In addition, OL has often an intentional perspective seeing learning as a process of improving actions or performance through better knowledge and understanding (Fiol and Lyles 1985; Jerez-Gomez et al. 2005; Crossan et al. 1999).

In the context of sustainable development, OL can be seen especially from a strategical management point of view as a means of gaining alignment between the organization and its environment to maintain long-term competitiveness and the survival of a company (Hambrick 1983; Summers 1980). OL contributes to competitive

advantage (March 1991; Camison and Villar-Lopez 2011), which promotes in the literature especially economic sustainability. However, from an environmental alignment perspective, OL can address all of the three dimensions of sustainability by answering to the question of how a company adjusts to their environment.

### Connection to Capability Building

OL is a sort of capability (Jerez-Gomez et al. 2005) and an essential part of organization's capability building (Kim 1998). In general, OL as a capability is considered an important element for a firm to successfully compete in a global marketplace (Prahalad and Hamel 1990). Moreover, the strategical management literature has a special interest toward OL, seeing it as an enabler of competitive advantage (March 1991; Jerez-Gomez et al. 2005) and lately as a source of sustainable competitive advantage (SCA) (Camison and Villar-Lopez 2011). SCA is possible when a company possesses heterogeneous resources and capabilities, which competitors have difficulty to imitate or substitute (Camison and Villar-Lopez 2011).

Although competitive advantage is a popular angle toward OL, the capability building perspectives vary a lot due to the multidisciplinary nature of the OL research. OL contributes among other things to adaptation and change (March 1991), promotes innovation capabilities (Camison and Villar-Lopez 2011), enables strategic renewal capabilities (Crossan et al. 1999), and supports the exploitation of organization intellectual capital (Hsu and Fang 2009).

In the OL literature, there is a common assumption that learning will improve future performance of company (Fiol and Lyles 1985). Moreover, it is commonly accepted argument that capability building happens on different levels of learning differing on the inputs and outputs, and it is important to work within OL on all of the levels (Fiol and Lyles 1985). This kind of perspective makes explicit characteristics of OL a capability building capability.

Accordingly, Fiol and Lyles (1985) summarize, based on a broader literature review, that organizations can be seen to learn and improve their performance on two levels. First level is a lower-level

learning, which results in behavioral outcomes through repetitive routines of solving problems (Fiol and Lyles 1985). Organizational improvements narrow down to detecting and correcting errors within a given system of rules (Argyris and Schön 1978). Second-level learning is higher-level learning, which happens on cognitive level building new insights and understanding on individual and collective basis (Fiol and Lyles 1985). It aims at adjusting organization's overall rules and norms and results in long-term effects and structural changes (Fiol and Lyles 1985). In addition, higher-level learning promotes a firm to go beyond an adaptive learning and focus on the learning level required to question the organizational system in force and make changes in search for more innovative and flexible alternatives (Fiol and Lyles 1985). This kind of learning is called generative learning (Fiol and Lyles 1985). Moreover, also a third level of learning can be distinguished; the so-called deutero-learning is seen as a concept of learning to learn (Bateson 1972). This kind of learning takes OL itself as an intellectual capability and as an area of development and enables an organization to question even broader the reasoning behind its practices (Bateson 1972).

### Evolution of the Theory

OL has been a focus point of different fields of research at least from the 1960s organizational research (Crossan et al. 1999). However, due to its multidisciplinary nature, the research has been rather fragmented, and different researchers have applied the concept of OL to different purposes in different domains (Huber 1991; Crossan et al. 1999). The topic has raised interest in fields such as psychology, sociology, management, information science, and innovation. The notion of OL is widely accepted; however, there is no commonly agreed model of OL (Fiol and Lyles 1985), and there has not occurred convergence in the theoretical frameworks (Crossan et al. 1999).

Some form of roots of OL can be lead to observations on individual learning in an organization (Shrivastava 1983; Senge 1990). Despite this, it has been early understood that learning is a dynamic process going from the individual to the group level and then to the organizational

level (Huber 1991; Crossan et al. 1999). As Simon (1991) explains it, what an individual learns in an organization greatly depends on what is already known by the other members of the organization. Fiol and Lyles (1985) have identified that the discursion in OL literature has varied greatly between focus in behavior and cognition, which again from the concepts' differing natures has caused difficulties to find integrated framework to the concept of OL and how to measure it. Lately, OL research from the strategical management point of view has evolved to the phase where different guidelines are identified in order to improve the effectiveness of OL in a company (Camison and Villar-Lopez 2011; Jerez-Gomez et al. 2005).

**Microfoundations of Organizational Learning**

Some microfoundations can be identified for the concept of OL that contribute to long-term

competitiveness and sustainable competitive advantage (SCA). In other words, the micro-foundations can be considered as essential elements that support effective OL. The following (Tables 5, 6, 7, and 8) is a collection of such OL dimensions and enablers that contribute to SCA. The authors behind the descriptions and their well-established articles are chosen because they provide different perspectives to topical dimensions of OL and thus support getting a wider understanding on OL.

Zollo and Winter (2002) present broadly generalizable and commonly accepted elements of OL that support dynamic and operational capabilities. These three elements can be also characterized as three typical learning mechanisms. Table 5 describes these elements.

Similarly, Crossan et al. (1999) in their framework for OL describe four processes that contribute to organization's strategic renewal. Table 6

**Capability Building Through Dynamic Capabilities and Organizational Learning, Table 5** Learning mechanisms contributing to sustainable competitive advantage (Zollo and Winter 2002)

Experience accumulation	Seeks to bring about desirable changes in the existing set of operations. Routines involve 1. Execution of known procedures 2. Search for desirable changes in the existing set of operating
Knowledge articulation	Collective learning via individuals expressing their opinions and beliefs, challenging and engaging confrontations with each other. Here, implicit knowledge is articulated through collective discussions, debriefing sessions, and performance evaluation processes
Knowledge codification	Codification of individual's understandings of performance implications of internal routines in written tools. It is a supporting mechanism for an entire knowledge evolution process, which, e.g., facilitates the generation of new proposals to change the currently available routines and identifies strengths and weaknesses in the proposed variations to the current set of routines

**Capability Building Through Dynamic Capabilities and Organizational Learning, Table 6** OL processes contributing to organization strategic renewal (Crossan et al. 1999)

Intuiting	Subconscious process of developing insights either through (1) expert intuition, which refers to process of past pattern recognition, or (2) entrepreneurial intuition, which is future possibility oriented action generating new insights and innovations. Inputs in such a process are different experiences and images. Outcomes are forms of metaphors
Interpreting	Picking up conscious element of the individuals' learning process, where individuals develop cognitive maps about various domains in which they operate. Language plays a key role in creating cognitive maps. In groups of people, discussion plays important role to create shared understanding
Integrating	Collective action toward shared meaning where individuals or a group shares practice and has a continuous conversation. Dialogue as a collective thinking and inquiry is essential part of integrating. Through dialogue a group can evolve new and deeper shared understanding
Institutionalizing	Means for organizations to leverage the learning of the individual members. This process is embedded in the organization systems, structures, strategy, routines, prescribed practices, and investments. Emphasizes that OL is different from the simple sum of the learning of its members

**Capability Building Through Dynamic Capabilities and Organizational Learning, Table 7** Top four OL capability areas to address by organization managers (Jerez-Gomez et al. 2005)

Managerial commitment	<p>Management should recognize and provide decisive backing toward OL. Identified factors from the literature are</p> <ol style="list-style-type: none"> <li>1. Managerial backing</li> <li>2. Shared vision and mental models</li> <li>3. Personal efficacy</li> <li>4. Leadership commitment</li> <li>5. Strategic intent</li> <li>6. Leadership and intention</li> <li>7. Involved leadership</li> <li>8. Facilitative leadership</li> <li>9. Learning orientation</li> </ol>
Systems perspective	<p>Collective conscience among the members of an organization to allow a company to be seen as a system in which each element makes its own contribution. Identified factors from the literature are</p> <ol style="list-style-type: none"> <li>1. Shared vision</li> <li>2. Systems thinking</li> <li>3. Systemic thinking</li> <li>4. Systems perspective</li> <li>5. Clarity of purpose and mission</li> <li>6. Systems orientation</li> </ol>
Openness and experimentation	<p>Climate of openness that supports new ideas and viewpoints, both internal and external. Environment that enables individual knowledge to be renewed, expanded, and developed. Identified factors from the literature are</p> <ol style="list-style-type: none"> <li>1. Openness to new ideas</li> <li>2. Independent problem-solving, continuous innovation, and experimentation</li> <li>3. Openness and creativity</li> <li>4. Entrepreneurship</li> <li>5. Operational variety, multiple advocates</li> </ol>
Knowledge transfer and integration	<p>Organizational knowledge based on the transfer and integration of knowledge acquired individually toward collective corpus of knowledge. Identified factors from the literature are</p> <ol style="list-style-type: none"> <li>1. Teamwork</li> <li>2. Team learning</li> <li>3. Integration of internal knowledge</li> <li>4. Knowledge transfer</li> <li>5. Transfer of knowledge and teamwork and group problem-solving</li> <li>6. Team orientation and memory orientation</li> </ol>

describes these processes in chronological order from individual learning processes of intuiting and interpreting to group learning process of integrating and finally OL process of institutionalizing. In the framework, the OL is described cyclical by its nature, and thus these different hierarchical levels of learning feed each other dynamically

Jerez-Gomez et al. (2005) have identified four core dimensions, where an organization should show a high degree of learning in order to state high-level learning capability. These dimensions are managerial commitment, systems perspective, openness and experimentation, and knowledge

transfer and integration. These four areas of OL capability are presented in Table 7

Correspondingly, in his paper *Crisis Construction and Organizational Learning: Capability Building in Catching-Up at Hyundai Motor*, Kim (1998) presents dimensions of OL that have enabled a company from a developing country to achieve competitive advantage starting as a small novice within its reference industry and becoming within four decades a global competitive player.

The presented descriptions of micro-foundations in OL represent widely accepted views within the SCA context. As described

**Capability Building Through Dynamic Capabilities and Organizational Learning, Table 8** Elements of OL in an imitative catching-up process (Kim 1998)

Absorptive capacity	Learning capability to assimilate external knowledge, imitate it, and use it. Absorptive capacity has two important elements: <ol style="list-style-type: none"> <li>1. Prior knowledge base, which consists of individual units of knowledge available within the organization. Migratory knowledge affects the building of the prior knowledge</li> <li>2. Intensity of effort, which represents the amount of energy invested by organizational members to solve problems</li> </ol>
Externally evoked and proactively constructed crises	In crisis a company invests heavily in the acquisition of new knowledge to overcome the crisis in the shortest possible time. Crises enable major changes in an organization. Crises may originate in three ways: <ol style="list-style-type: none"> <li>1. Due to external conditions</li> <li>2. Deliberately by an external principal such as government</li> <li>3. Internally constructed by top managers</li> </ol>
Learning orientation	Determines the practice of how organizations acquire, share, and use knowledge. It affects the spiral process of knowledge conversion. Orientation emphasizes different focus points toward learning such as duplicative imitation, creative imitation, or innovation
Organizational factors	Affect formal and informal processes and structures that can facilitate OL. Such factors are <ol style="list-style-type: none"> <li>1. Intention</li> <li>2. Autonomy</li> <li>3. Fluctuation and creative chaos</li> <li>4. Redundancy</li> <li>5. Requisite variety</li> <li>6. Leadership</li> </ol>

earlier, the lack of convergence in OL literature makes it rather difficult to reach completeness in describing such microfoundations. Zollo and Winter (2002) along with Crossan et al. (1999) represent in many ways different integrations of earlier OL theories. Jerez-Gomez et al. (2005) complement this and provide important research results based on empirical evidence, which OL in general is still in many ways lacking. Finally, Kim (1998) deviates to some extent from the other descriptions but points out well the diversity of OL literature. The descriptions Kim (1998) resonates with companies are also from development countries.

## Discussion and Conclusions

Capabilities form a hierarchical structure in which operational capabilities define firm's competence in today's business, while OL and DC lie deeper in the organization affecting the firm's competitiveness in a longer term. Operational capabilities can be considered as zero-level capabilities, and

DC and OL are on levels from 1 to n. Knowing the exact level of a certain dynamic capability or OL enabler is many times irrelevant. However, understanding the causalities between capabilities is important because it allows firms to take a systematic approach for capability development and focus their development resources, not only into operational capabilities but also to capabilities on higher hierarchical levels.

Both, OL and DC, explain how firms can modify their operating routines. Despite of this similarity, they are somewhat different if viewed in the context of the capability hierarchies. According to Zollo and Winter (2002), OL is the source for DC, as any capabilities have to be learned in the first place. In addition, while a dynamic capability is characterized by structured, persistent, and planned activities enabling the evolution of operational routines, OL can be more creative, unpredictable, and discontinued (Zollo and Winter 2002). However, in a situation where certain learning mechanisms in an organization become systematic, OL becomes as "second-order" DC (Collis 1994). Furthermore, OL can

also be considered to be a dynamic capability itself (Pavlou and Sawy 2011).

The purpose of this encyclopedia entry was to give reader a view on how firms build their capabilities and what kind of enablers form the ability to renew operational capabilities. Two theories, DC and OL, were chosen as sources of identification of the enablers. Tables 1, 2, 3, 4, 5, 6, 7, and 8 present views of several relevant authors on these enablers. However, giving comprehensive descriptions on the dimensions of the theories or making a systematic comparison between them was beyond the scope of this entry.

## Cross-References

- ▶ Business Environment: Emerging External and Internal Pressures for Sustainable Production
- ▶ Economic Competitiveness: An Overview of Multilevel Concept
- ▶ Economic Growth and Long-Term Competitiveness: Contribution of the Private Sector
- ▶ Social Sustainability and Continuous Learning in the Circular Economy Framework
- ▶ Sustainable Competitiveness at the National, Regional, and Firm Levels
- ▶ Top Management Involvement and Role in Sustainable Development of Companies

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PUBLICATION  
3

**Social Capital Characteristics in R&D Project Networks**

Majuri, M., Lanz, M.

Proceedings of PICMET '18: Technology Management for Interconnected World.  
doi: 10.23919/PICMET.2018.8481775

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# Social Capital Characteristics in R&D Project Networks

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Network research has multiple approaches that offer knowledge related to multiple network types. This article identifies and discusses social capital characteristics in the context of government-funded R&D project networks. Previous literature on this context has typically focused on collaboration between universities and firms while our interest is solely on interfirm relationships. Secondly, the previous literature on interfirm collaboration concerns typically other types of networks such as strategic alliances. We argue, that to understand the dynamics of inter firm collaboration in R&D project networks, the research needs to be conducted in coherent environment. Data for this qualitative research was collected by interviewing 18 firm representatives who had experience on participating government-funded R&D projects. We recognized social capital characteristics in R&D projects and organized these findings under structural, cognitive and relational dimensions of social capital. Results indicate that project networks' social capital characteristics differ in many parts from strategic alliances and thus support our argument. The results can be exploited by project coordinators, innovation officers and project network members to facilitate the interfirm collaboration in R&D project networks.

## I. INTRODUCTION

One of the major governmental support mechanisms to accelerate firms' R&D is funding joint R&D projects. Indeed, it has long been recognized that firms may benefit greatly from the collaboration in their R&D activities. The motives of collaboration vary from cost savings to benchmarking. An important determining factor of this collaboration is social capital, which by definition of Nahapiet and Ghoshal [1] is the sum of the actual and potential resources embedded within, available through, and derived from the network of relationships possessed by and individual or social unit. Social capital facilitates information exchange, reduces need for formal control and increases possibilities to have influence inside organizational networks [2]. These potential benefits make social capital a valuable asset for R&D networks as they aim for high productivity of R&D results. Still, the concept of social capital is ambiguous and its multiple dimensions and variables may cause complexity for the social capital evaluation in networks. Additionally, as Inkpen and Tsang [3] proposed, the mechanisms and characteristics of social capital have different features in different types of networks. These social capital characteristics have not been studied in the context of R&D project networks.

This paper contributes to previous literature by identifying the social capital characteristics in R&D project networks.

More specifically, we focus on the inter-firm collaboration in projects that have received public funding. The findings are compared to the social capital characteristics of strategic alliances to emphasize the unique characteristics of R&D project networks. With the comparison, we aim to emphasize the uniqueness of project networks and argue that project networks can not be properly understood by research focusing on other network types.

In the next two sections we discuss the concepts of R&D project networks and social capital dimensions. Then we describe the methodology used in this research. Fifth section presents the findings. In last section we make conclusions from the findings, discuss the results and future research plans.

## II. R&D PROJECT NETWORKS

Podolny and Page [4] defined network, when considered as a form of governance, as any collection of actors that pursue repeated, enduring exchange relation with one another and, at the same time, lack a legitimate organizational authority to arbitrate and resolve disputes that may arise during the exchange. This approach allows easy recognition of a network in research purposes. However, due to several variables of networks, further identification of network type can be challenging.

One of the most studied types of networks are strategic alliances which Gulati [5] defined as voluntary arrangements between firms involving exchange, sharing, or co-development of products, technologies, or services. This definition includes wide variety of different forms of networks and the R&D networks can be seen as a subcategory of strategic alliances. Strategic technology alliances is more accurately defined networks type. Hagedoorn and Duysters [6] defined it as a network in which companies acquire and develop R&D-related knowledge that will help them to differentiate their technological performance from other companies. Similar network type is research consortium, which was defined by Doz et al. [7] as a legal entity established by two or more organizations that pool resources and share decision making for cooperative research and development activities.

However, these network types do not describe accurately enough the networks we studied. In our study the projectivity is such an essential characteristic of the network that we decided to include the project into the name of the network type. Typically, projects are just means for the network members to achieve their R&D intentions and projects are not seen as a defining factor of the network type. In our study the networks

did not exist before the project and in most cases, the members had no previous history of working with each other. Networks also dissolved after the project ended. Only random collaboration between individual companies existed before and after the projects

### III. SOCIAL CAPITAL DIMENSIONS

Social capital started to receive popularity among researchers in the 1980s and in the 1990s, it was already a widely used concept among economic scientists [8]. Depending on the research focus, different aspects of social capital have been emphasized. In 1998 Nahapiet and Ghoshal [1] integrated different facets of social capital into three dimensions: structural embeddedness, relational embeddedness and cognitive dimension. Although, authors have since offered different structures for evaluation of social capital (e.g [9]), we chose to use the dimensions by Nahapiet and Ghoshal for structuring our findings. There are three reasons, why we chose to do so. First, our findings on social capital characteristics fit naturally into this structure. Second, the structure was used by Inkpen and Tsang [3] to investigate social capital's role in facilitation of knowledge transfer in different networks types. As we compared our findings to their analysis on the social capital characteristics of strategic alliances, it was appropriate to use the same social capital dimensions. Third, a thorough comparisons between different definitions and dimensions of social capital was out of scope of this research. Table 1 gives a brief descriptions of the social capital dimensions based on Nahapiet's and Ghoshal's [1], and Inkpen's and Tsang's [3] research.

TABLE I. SUMMARY OF SOCIAL CAPITAL DIMENSION DESCRIPTIONS

Social Capital Dimension	Description
Structural	Observes network as a whole. Describes ties between network members, e.g. connectivity and density of ties. Also, hierarchy and stability of the network are observed in this dimension.
Cognitive	Includes network characteristics that increase shared meaning and understanding between the network members, e.g. shared culture, goals and language.
Relational	Observes characteristics of personal relationships and emotional attachments, e.g. trust and trustworthiness, norms, expectations and identity.

### IV. METHODOLOGY

Our research objective is two-folded. First, to deepen understanding of social capital in the context of R&D project networks. Second, to evaluate the uniqueness of R&D project networks as a network type from social capital perspective.

For the purposes of the first objective, we used qualitative research method. The research data had been collected previously through semi-structured interviews. The original aim of the interviews was to evaluate in what extent the interfirm interaction and knowledge co-creation occurs in government-funded R&D projects. More accurately what are

the circumstances that facilitate the co-creation of knowledge, what kind of knowledge was created and what was the project coordinators role in the facilitation of the new knowledge. Although the aims of this paper were not recognized in the planning phase of the interviews, the gained data provided sufficient information to evaluate the social capital characteristics in the context.

Interviews began with a short introduction to the research aim, which was to deepen the understanding on interfirm interaction in R&D projects. In the second phase, the interviewees identified phases of the project based on project milestones. Typically there was three to eight identified phases. Thirdly, interviewees evaluated the amount of interaction with other project member in each phase of the project. Then the discussions concentrated on phases in which the interaction had been active. Main discussed topics were related to the direct and indirect circumstances that led to the interfirm interaction e.g. atmosphere of collaboration, resourcing issues, motivation towards interaction, openness of communication and nature of transferred/created knowledge. Also, the business value that followed from interaction was discussed. All the interviewees were firms' primary project participants. One interview was made in each firm resulting 18 approximately 1,5h long interviews. All interviews were transcribed and coded using Atlas TI program.

For the purposes of the second research objective we compared our findings to typical social capital characteristics of strategic alliances. Strategic alliances were chosen for two reasons. Firstly, from network governance perspective they are similar to R&D project networks, as both network types have semi-structured governance. Secondly, strategic alliances are one of the most studied network types and as such they make an interesting comparison target.

The real-world setting of the research is illustrated in the fig. 1. 2. All companies received funding from Tekes, which is the biggest public funding agency in Finland for research, development and innovation. For companies 11-18 Tekes funding came through programs of Strategic Centres for Science, Technology and Innovation, SHOKs. These centres were organized as limited companies around clusters of public-private partnerships and they were one of the main instruments of Finnish innovation policy [10]. However, SHOK funding has since been canceled and their activities have ended or changed significantly. Projects 1 to 3 received funding straight from Tekes. The share of Tekes funding was typically 25 to 30%.

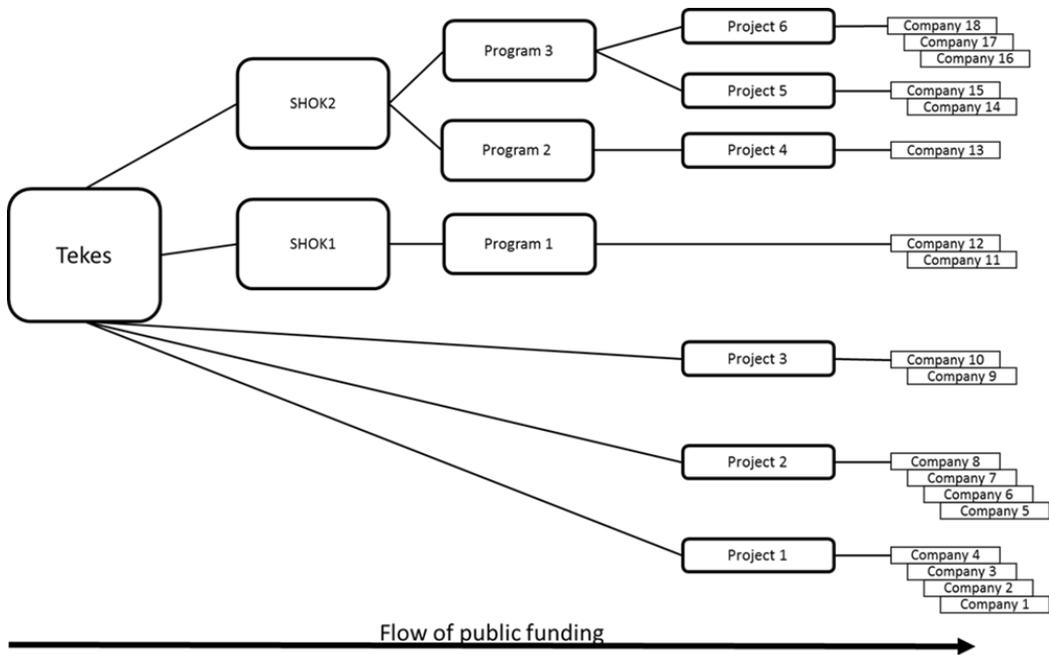


Fig. 1. The real-world setting of the research.

## V. FINDINGS

Findings are structured according to structural, relational and cognitive dimensions of social capital. Table 2 presents the summary of social capital characteristics identified in R&D project networks and compares these findings to typical characteristics of strategic alliances. The following chapters explain the findings in more detail.

### A. Structural characteristics

**Network ties.** In case of SHOK based projects and programs the social ties often existed before the projects begun which strengthened the intermember ties. In project 3 the intermember ties created basis for the strong social ties. In project 1 and 2 the project both intermember ties were weak and no strong social ties were formed.

*The project was coordinated in such a way that it included plenty of open discussions in a good spirit, so we became a good team*

**Network configuration.** Networks were nonhierarchical, even in situations when firms from same value chains participated the projects. Still, some signs of social hierarchy could be noticed, e.g. representatives of large firms were to some extent role models for representatives of smaller ones. Connectivity varied greatly between projects and companies.

When strong social ties existed, the firm boundaries did not seem to have any effect on interactions. Network density varied. With active members the network density was high. Projects acted as a useful collaboration platform that active members used to connect with each other. Some members took a passive role in the projects, so their participation increased only the potential density of the network.

**Network stability.** All project networks had a high rate of stability during the projects if measured solely by the change of memberships. In some occasions, there was significant changes in the strength of ties and in amount of interfirm interactions, which is comparable to a situation where a new member joins the network or leaves it.

### B. Cognitive characteristics

**Shared goal.** There was variation how actively firms interacted in the project planning phase. Typically research institutions had a major role in forming the application and project plan. In project 3 the project goal was common by its nature. In other projects firms' goals were compatible, but not always synergic since they were able to achieve their goals without interactions with other firms. In program 1 the goals were abstract and R&D themes were defined more accurately quarterly as project proceeded. In SHOK programs the coordinators evaluated the genuine interest of member candidates and left out firms which had wrong expectations. Interviewees felt that the existence of project plan does not mean that the members have a shared understanding on the project tasks and goals.

TABLE II. SUMMARY OF FINDINGS OF SOCIAL CAPITAL CHARACTERISTICS IN R&D PROJECT NETWORKS AND COMPARISON TO STRATEGIC ALLIANCES

Social capital dimensions	Network type	
	R&D project networks	Strategic alliances
Structural: Network ties	Intermember and social ties support each other	Intermember ties determining social ties within an alliance
Structural: Network configuration	Nonhierarchical, significant variation in connectivity and density	Nonhierarchical, possibility of exploiting structural hole positions
Structural: Network stability	Stable memberships	High rate of instability
Cognitive: Shared goal	Shared written goals, which may not be internalized by the members. Goals rarely common.	Compatible goals but rarely common goals
Cognitive: Shared culture	Firm representatives' adaptation to network's culture	Cultural compromise/conflict among members
Relational: Trust	Low risk of opportunism. Trust formation supported by absence of competitors, NDAs and "small circles"	Significant risk of opportunism, behavioral based trust

*The discussion (in the planning phase) are important. All actors come together and share their dreams and challenges. The common denominators are identified and concrete action plan is created. The described (planning) process does not always come to an end...*

**Shared culture.** Interviewees did not report any culture related conflicts. Contrary, in two occasions the cultural characteristics of a large firm member were benchmarked by project members. In program 1 the program plan was loose, but network had relatively strong shared culture of active and open knowledge sharing. The consortium consisted of many members who had previous experience working together in a similar type of a program. The members represented same business field in which hierarchy levels are typically low.

*I dont think, that anywhere else in Finland information has been shared this openly, even companies A and B (competitors) held presentations together*

*Systematic working culture is a good thing. It is nice, when a larger company takes care of a smaller company (interviewee's organization) and shows how things are done.*

### C. Relational Characteristics.

**Trust.** All project members signed a non-disclosure agreements before the project started or in the early phase of the project. None of the interviewees reported any problems related to lack of trust or a member behaving untrustworthy. Overall, trust issues were brought up rarely in discussions. Still, in project 3 interviewees informed that trustful atmosphere in meetings supported discussions. In projects 1 and 2 the interaction between companies was almost non-existent so naturally trust issues were not relevant. In program 1 no trust related problems existed even that some members were competitors with each other. The program focused on process development (not product) and interviewees felt that this minimized the risk of opportunism and thus increased trustfulness. In project 4 the interviewee felt that absence of competitors increased openness. In project 5 the interaction between firms was limited to formal meetings and visits in which firms presented their R&D results. Trust related issues were not brought up. In project 6 the interfirm interaction was active. Representatives from companies 16 and 18 had previous history working together and continued deep collaboration during the project.

## VI. CONCLUSIONS AND DISCUSSION

We studied social capital characteristics in R&D project networks under three dimensions of social capital: structural, cognitive and relational dimensions. The variation of characteristics between projects in structural dimension seems to be high. Only membership stability was high in all studied cases. Intermember and social ties supported each other, depending on whether previous collaboration between individuals had existed. Being SHOK-based project seemed to increase the change of previous collaboration. The networks were mostly non-hierarchical, although some signs of hierarchical behavior could be noticed in dyadic relationships between suppliers and customers and between large and small companies. Density and connectivity varied between projects. On our previous study [11] we analyzed explanations given by the interviewees from companies 1-8 for the lack of collaboration in the projects one and two. The explanations fell into three categories: own R&D goal was different compared to the ones other companies had, project consortium changed into less synergic during the project implementation and there was lack of resources.

Cognitive dimension of social capital focuses to evaluate to what extent the culture and goals are shared in the networks. As all projects were receiving public funding, the networks had had to define the R&D goals as a part of the application phase. Except the project 3, the goals were compatible but not common. However, there was uncertainty whether all participants genuinely committed to or internalized the written goals in the project plan. In addition, there was concern that, goals were defined too abstract to have definite meaning for all the members. The cultural issues were rarely brought up in the interviews. Typically, members represented same business fields which increases the similarities of corporate cultures and so reduces the likelihood of culture related clashes. Also, all participating firm members but also participating individuals were Finnish which in turn contributes to the cultural similarity.

Although under relational dimension of social capital can be observed several characteristics related to personal relationships, in this article we focused on trust. Mainly because trust is so central issue in the network related literature and it was also the only characteristic of relational dimension analysed by Inkpen and Tsang in 2005. Surprisingly trust or trustworthiness did not seem to be a central issue in the studied cases and lack of collaboration can be explained by other reasons such as low motivations towards collaboration or lack of resources. We have identified four possible explanations for this. First, in a small country like Finland acting untrustworthy is potentially very risky. The person or organization breaking the trust, might get bad reputation which would cause severe difficulties to the future collaboration opportunities. Being aware of this situation makes people trust each other in principle and no separate trust building is needed. Second, in many projects members were able to achieve their individual goals without other members' competences, so competence trust was not required. In such projects the collaboration was thin, so there was no need for good-will trust either. Third, in some cases the project topic was such that the members were able share their project results and project related knowledge without concerns of misuse of the knowledge. Fourth, there is also a possibility that for some reasons trust is a topic that interviewees did not want to discuss.

Although, our sampling size was small, it is quite uniform and so generalizable with certain limitations. In larger countries, in which social distances are longer compared to Finland, it is likely that trust issues emerge more strongly. Also different funding policies will create different kind of circumstances for collaboration and thus effect the characteristics of social capital. Different fields of industry will probably have different conditions for collaboration, since the e.g. the maturity levels vary between industry fields. Indeed, some signs of this could be noticed in our study, in which open sharing of information came more naturally in ICT-oriented projects compared to the projects in mechanical industry. The major diversity seems to come from whether or not the project belonged to a larger program. Wider programs, that act as an umbrella for projects, offer a platform for projects to intensify the intermember collaboration already in the early phases of the projects.

This article aims for two-folded contribution. First, it identifies social capital characteristics of R&D project network. Second, it describes the uniqueness of project environment of collaborative R&D. Our findings suggest that, from social capital perspective, R&D projects networks are a unique form of collaboration. R&D project networks have many similarities with other network types, e.g. strategic alliances. Still, they have unique characteristics that have significant effect on the dynamics of R&D project networks.

Our future work will concentrate on exploring possibilities of project coordination and R&D policy making to influence the social capital characteristics in R&D project networks to support knowledge transfer and co-creation.

## VII. ACKNOWLEDGMENT

The research was funded in part by Tekes, the Finnish Funding agency for Technology and Innovation. We thank Professor Saku Mäkinen for his valuable comments during the research process.

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# PUBLICATION

## 4

### **Analysis of Inter-firm Co-operation in Joint Research and Development Projects**

Majuri, M., Nylund, H., Lanz, M.

Nääs I. et al. (eds) *Advances in Production Management Systems. Initiatives for a Sustainable World. APMS 2016. IFIP Advances in Information and Communication Technology*, 488, 536-543.

doi: [https://doi.org/10.1007/978-3-319-51133-7\\_64](https://doi.org/10.1007/978-3-319-51133-7_64)

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# Analysis of Inter-firm Co-operation in Joint Research and Development Projects

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**Abstract.** Companies need to renew themselves to be able to compete in the dynamic global markets. Especially for the SMEs this is often challenging due to their weaker risk tolerance and fewer resources. Co-operation is often considered to be effective way to tackle these challenges and considerable amount of public funding has been directed to stimulate this co-operation. Still, deep research and development (R&D) co-operation between companies exists rarely. The paper presents qualitative analysis on co-operation in two joint R&D projects. The level of inter-firm co-creation in studied cases was low. This was explained by lack of resources, differences of R&D goals and changes in project consortium. Finally, we present two possible solutions to increase the level of inter-firm co-creation in joint R&D projects.

**Keywords:** Networks, Renewal, Innovation, R&D

## 1 Introduction

Rapid changing markets and increasing competition have led to a situation where ability for renewal has become one of the dominant capabilities in the pursuit of competitive advantage [1]. The renewal may focus on processes, offering or business concepts and can be radical or incremental by nature. Challenges related to renewal are somewhat different between large companies and SMEs. SMEs have typically less bureaucracy and more concentrated ownership, which in general support agility. Additionally, with fewer resources, the personnel of SMEs' are used to work in wider scope of processes, which in turn supports flexibility. On the other hand, compared to the large companies, SMEs' have typically weaker risk tolerance, smaller knowledge base, fewer sales channels and narrower offering. All of these factors can be considered essential for successful renewal, development and innovation. Inter-firm co-operation creates a major opportunity to tackle these challenges and altogether enables firms to achieve stronger position than they could alone [2].

In general, deep inter-firm R&D co-operation between SMEs in the Finnish technology industry is rare [3]. On the other hand, several public funding instruments require this co-operation and multiple organizations have been established to support the co-operation. Focus of the paper is on collaborative R&D projects that received

funding from Tekes, Finnish Funding Agency for Innovation. The paper increases understanding on the challenges and opportunities the companies are facing in their co-operation attempts during these projects. Research data was collected with eight semi-structured company interviews in two separate R&D projects.

## **2 Joint Research and Development Projects**

The research concerning inter-firm R&D co-operation is fragmented. Several frameworks and concepts from multiple fields of science have been presented to model the dynamics of inter-firm co-operation. Majority of the studies concerning inter-firm co-operation seem to be quantitative by their nature, although this was not systematically studied. In recent years concept of open innovation has got a lot of attention. Open innovation processes includes outbound, inbound and coupled processes [4] from which coupled processes are closest to the topic of this study. However, the research focusing on coupled processes does not seem to include inter-firm joint R&D projects in which the companies are from different value chains.

Hagerdoorn [5] has created classification for co-operative agreements based on the amount of the organizational interdependence, which can be considered to be a central dimension defining the mode of co-operation. The classification has four main modes: (1) Joint R&D ventures, (2) Joint R&D and technology exchange agreements, (3) Equity investments and (4) Customer-supplier relationships and one-directional technology flows. The second mode is divided into three categories: joint research pacts, joint development agreements and technology sharing agreements. Study presented in this paper contributes to the areas of joint research pacts and joint development agreements.

Barnes et. al. [6] have identified 40 success factors for inter-firm co-operation which they have divided into six categories: choice of partner, project management, universal success factors, ensuring equality, monitoring environmental influences, project manager and choice of partner. Lee et. al. [7] have summarized intermediary's role in SME innovation networks based on literature review into framework that consists of five. Categories: Network Database, Network Construction, Network Management, Culture of co-operation and Facilitation of co-operation. Frameworks that illustrate the characteristics and dynamics of R&D inter-firm network are presented by e.g. Kirkels [8], Esterhuizen et. al. [9], Möller et. al. [10], and Dasgupta and Gupta [11].

The frameworks have plenty of similarities but they are still different. A conclusion can be made, that the inter-firm co-operation as a phenomenon is heavily case dependent. None of studies dealt with the same situation as ours. Therefore it is justified to increase the understanding on inter-firm R&D co-operation from perspective of this paper. At least the following features can be considered to be defining in our study: public funding, significant role of research institute, project-centeredness, formality, non-equity, non-value chain and technological orientation of R&D topics. Considering the high volume of joint R&D projects receiving public support they are

surprisingly rarely in the focus of the qualitative studies, which could provide in depth knowledge on the phenomenon.

### 3 Method

Priority of our research was to deepen the understanding on actual experiences that companies had on inter-firm co-operation in publically funded join R&D projects. Research approach was qualitative and inductive. This approach was chosen due to fragmentation of the previous research and case dependence of the phenomenon dynamics.

The data was collected by interviewing eight persons from eight companies that had been participants in collaborative R&D projects funded by Tekes. Interviews were semi-structured and they lasted 75 minutes on average. Central answers concerning project phases, quantity and quality of co-operation, goal achievement and co-operation characteristics were collected into an excel sheet that was visible for the interviewee during the interview. The interviewees were asked to define the project phases freely according to project goals they found relevant. Illustration of the excel sheet is presented on table 2. There was also data collected concerning the co-operation with research institutes, but it is not in the focus of this paper.

All interviewees were the major participants in the projects from their companies. Introduction for the interviewee about research objectives was kept short to avoid inducement. All interviews were recorded and transcribed. Atlas TI computer program was used for qualitative coding.

**Table 2.** Excel sheet base filled with the interviewee.

Number of the project phase	1	...	n
Goal of the project phase			
The amount of the collaboration with research institutes 0=none, 1=little, 2=moderately, 3=plenty			
The quality of the collaboration with research institutes 0=poor, 1=moderate 2= high			
The amount of the collaboration with other companies in the project			
The quality of the collaboration with other companies in the project			
Goal achievement 0=not achieved, 1=achieved partially, 2= achieved well			

Aim of the paper is to answer the following research questions:

1. What characteristics companies associate with high and low quality inter-firm co-operation?
2. What reasons explain the realized amount of co-operation?

Additionally, the paper gives suggestions for new project structures that would increase the quality and quantity of inter-firm co-operation in R&D projects. There is

also data presented on the amount of co-operation between companies and also between companies and research institutes. However, this data cannot be generalized due to small sample size, but it can be considered to be useful for planning future research and also to stimulate the public discussion on the matter.

The research presented in this paper is part of the ongoing research project called Renaissance of the Regions (ReRe) – Challenging the Status Quo of Innovation Policy Implementation in Regional Manufacturing Networks. Project goal is to create improved methods and means for public or private network coordinators to support and develop the innovation process in SME networks. To be able to work efficiently it is necessary that the coordinator has an understanding on what characteristics high quality co-operation consists of. Understanding on the mechanisms how to influence those characteristics and on the mechanisms how those characteristics influence the co-operation is also needed. Additionally, this understanding is valuable also for the companies. With deeper understanding they are able to manage their co-operation activities and capabilities more coherently to support their innovation co-operation with other companies.

Tampere University of Technology’s research goal in the ReRe project is to create generic model for evaluating the status of prioritized co-operation characteristics in DIR network (Development, Innovation, Renewal). Table 1 explains the research phases. The results and analysis presented in this paper contributes to the current state analysis. They also create valuable information for planning a web survey on phase 2.

**Table 1.** Research phases.

Phase No.	Phase	Methodology
1.	Current state analysis	Literature review and qualitative study (interviews)
2.	Generalization	Quantitative study (web survey)
3.	Deepening the understanding	Qualitative study (interviews)
4.	Synthesis	Combining and evaluation of the knowledge from phases 1 to 3 (expert workshops)
5.	Verification	Testing the model by using it to analyze 3 to 5 DIR networks

## 4 Interview Outcomes

Table 3 presents the amount of co-operation the interviewed company had with other companies and with the research institutes during the different phases of the project. It also presents the quality of the co-operation in each phase and how well the goals were achieved.

**Table 3.** Amount and quality of cooperation.

	C1	C2	C3	C4	C5	C6	C7	C8
The amount of the collaboration with research institutes 0=none, 1=little, 2=moderately, 3=plenty	0 3 3 0 0	2 3 1 1 0	3 1 0 1 3	0 2 0 3 0	2 1 2 2 2	2 2 2 1 1	1 0 3 2 1 2 0	3 0 1 0
The quality of the collaboration with research institutes 0=poor, 1=moderate 2= high	2 2	2 2 2 2	2 2 0 1	2 2	2 2 2 2 2	2 2 3 1 1	2 1 0 2	1 1
The amount of the collaboration with other companies in the project 0=none, 1=little, 2=moderately, 3=plenty	0 0 1 0 0	0 0 0 0 0	3 1 0 1 3	0 0 0 0	2 0 0 0	0 0 0 0 0	0 0 0 0 0	0 0 0 0
The quality of the collaboration with other companies in the project 0=poor, 1=moderate 2= high	2		2 2 2 2		2			
Goal achievement 0=not achieved, 1=achieved partially, 2= achieved well	2 1 1 2	0 1 2 2 1	2 2 2 0 0	1 2 0 0 2	0 2 2 2 2	2 2 1 1	1 2 1 2 2 2	1 2 1 2 2

Although the study sample is small and as such not generalizable, it was still surprising to notify how little inter-firm co-operation existed. With further analysis on the transcribed interviews we formed table 3, which includes explanations the companies gave for the low amount of inter-firm co-operation.

**Table 4.** Explanations for the lack of inter-firm co-operation.

C1	Company with synergetic business interests left the project in early stage. This was possibly due to financial challenges.
	Other companies were distant.
C2	Other companies had different focusses in their R&D.
	Company, that was considered as a potential partner, focused on different technology.
C3	Big customer, that encouraged C3 to participate, did not participate the "group project". The customer was not able to reach an agreement with other participating companies.
	Other companies were already in their own networks, and P3 was not able to fit into them.
C4	Other companies were interested in C4 part, but did not want to allocate resources to collaboration. From business perspective the times were difficult and this affected the resourcing.
	One potential company to do collaboration with left out just before project started
C5	Project topic in C5 was different. Other companies focused on product development when C5's aim was to develop their risk management processes.
	Insufficient resources in C5.
C6	R&D subjects were close, but not close enough to do collaborative development
C7	Lack of resourcing in C7. Collaboration would have required human resources from wide range of functions in C7)
	Scope of R&D was such that it did not lead to collaboration.
C8	Desired results were delivered with very little collaboration. Knowledge exchange between companies happened through research organization.

Due to small amount of inter-firm co-operation it was natural that the data did not offer much information on the co-operation characteristics. Since all inter-firm co-operation was considered by the interviewees' to be of high-quality (Table 2.) only characteristics describing high-quality can be listed. Characteristics describing high-quality inter-firm co-operation are listed below:

- Common vision
- Partner was showing trust
- Encouragement by the partner
- Desire to help
- Honest and straight dialogue
- Good relations
- Openness
- Experienced appreciation
- Similar commercial goals

## 5 Conclusions and Discussion

In this paper the characteristics of inter-firm R&D co-operation in the Finnish technology industry was discussed. The explanations for the lack of inter-firm co-operation in a joint research project, presented in Table 4, can be summarized with the following three categories:

1. Own R&D goal was different from the ones other companies had
2. The project consortium changed into less synergetic
3. Qualitative of quantitative lack of resources

The projects that we studied were put together mainly by research institutes which had their own research projects going alongside the companies' R&D projects. The construction phase of the projects, including putting the consortium together, is usually carried out fast. This means, that not much resources are allocated into finding companies with similar or synergetic R&D goals.

Sherer [12] divides the critical success factors for manufacturing networks into trust, commitment, selection choice, information technology, and intermediary. The role of an intermediary, which in our study was a research institute, is important at the construction phase of a project. An intermediary can facilitate networking both by selecting potential participants and aiding companies interested in participating in a R&D project. Barriers, such as conflicting goals and expectations can be eliminated by an efficient facilitation [13].

One challenge in the forming of the R&D project is, in addition to the putting the consortium together is a short time, is the small amount of potential companies that can be contacted. Research institutes typically rely on their existing contacts, which narrows down the selection choice of companies. Thorgren et al. [14] state that larger number of companies relates to a greater innovation. The greater number of companies increases the selection choice, which can lead to more synergetic R&D projects. In the forming phase, trust and commitment is mainly focused on the intermediate in that the potential companies are confident with the intermediate and are more willing to participate in a R&D project. Potential companies should have clear vision of the R&D project to invest into it [15].

Trust and commitment is essential in both forming and during a R&D project. During a R&D project the role of an intermediate changes more on supporting the partici-

pating companies in the trust and commitment issues between the participating companies [16]. The trust and commitment issues between the participating companies emphasizes during a R&D project. A company should have clear image of the benefits it can gain from the project. In the inter-firm co-operation an important issue is how the co-operation with other companies enhances their own objectives [17]. This requires open sharing of information and resources in that opportunities are clear, which is an evident benefit of a functional network [18].

The lack of resources can be explained with both lack of needed skills and lack of time dedicated to the project even when personnel with required skills exist. This can be explained with the short time of construction of a project. It is important that the participating companies are devoted to the ongoing R&D project. In addition to the role of the intermediate, top management of the companies should recognize the importance of the co-operation [19]. Two relatively different solutions can be identified to tackle these challenges.

The first solution we propose is that there should be knowledge available on the R&D goals of large amount of companies for the person who is coordinating the project planning, e.g. in some kind of database solution. This would allow contacting widely potential participants that have similar or synergic R&D interests. When companies with similar genuine R&D needs would be identified in early stages of the project planning, commitment inside the consortium would rise and fewer changes in the consortium would occur. It should also be noted, that in the studied cases the company participants did not interact together in planning phase and the first face to face meetings were organized after the projects had already started. It is quite likely, that the presented solution would also increase pre-project co-operation, besides increased co-operation during the projects.

In projects with public funding involved, the companies tend to define their R&D goals with narrow scopes and have often very little resources allocated into free innovative renewal. This is partly because the public funding system requires coherent narrowly defined plans and partly because of small R&D resources due to hard competition situation in many business fields.

The second solution we suggest would be a kind of hybrid model for the project plan. There would still be straightforward plans with narrow scopes but the project plan would also include resources for loosely defined collaborative R&D and interaction, e.g. topical workshops. This would create opportunities and space for new ideas that were not possible to be identified in the planning phase of the project. In the current model the project participants become sort of prisoners of the project plan. This leads often to minimal or zero slack and weak co-operation. This is problematic, because slack and co-operation can be considered to be cornerstones of innovativeness [20].

## **Acknowledgements**

The research presented in this paper is co-financed by Tekes, the Finnish Funding Agency for Technology and Innovation, and Tredea Oy, the Tampere Region Economic Development Agency.

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PUBLICATION  
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**Inter-firm knowledge transfer in R&D project networks: A multiple case study**

Majuri, M.

Technovation, 115.

<https://doi.org/10.1016/j.technovation.2022.102475>

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## Inter-firm knowledge transfer in R&D project networks: A multiple case study

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### ARTICLE INFO

#### Keywords:

Research and development projects  
Knowledge transfer  
Inter-firm collaboration  
Knowledge-transfer facilitation  
R&D projects  
Social capital

### ABSTRACT

Inter-organizational knowledge transfer is widely considered to be an important source of competitiveness in the extant literature and by innovation policymakers. This paper reports on a study that investigated inter-firm knowledge transfer in research and development (R&D) projects that received public funding. All projects took place in Finland and included university and/or research institute member(s). Based on multiple case studies, the significance of social capital in knowledge transfer was analyzed. Aspects that limited the knowledge transfer were identified and the effects of motivation on collaboration were evaluated. In certain cases, the knowledge transfer between firms was minimal and existed only in formal meetings. Surprisingly, the firms shared their R&D results openly with other network members, but this was not considered particularly beneficial.

The knowledge transfer was limited by changes in consortiums, changes in project duration and/or budget, differences in R&D interests, insufficient resources, and ability to achieve R&D goal(s) without collaboration. In cases with active collaboration, several features of social capital in combination with complimentary business goals were perceived as facilitators of knowledge transfer. Based on the results, practical implications for innovation policymakers and project coordinators, and directions for future research, are proposed.

### 1. Introduction

This article addresses inter-firm knowledge transfer (KT) in the context of research and development (R&D) projects receiving public funding. Currently, collaborative R&D and project-based collaboration are encouraged by several public national or international funding instruments and programs (Rajalo and Vadi, 2017), for example, the Horizon 2020 program in the European Union and the Co-Innovation funding instrument in Finland. R&D collaboration creates an opportunity for a firm to enhance the processes of knowledge creation and R&D and to explore new knowledge. Collaboration can reduce R&D costs (e.g., Littler et al., 1995), facilitate knowledge creation (e.g., Lawson et al., 2009), allow access to external knowledge benefitting from resources without ownership (Lavie, 2006), complement competencies (e.g., Hagedoorn, 1993), mitigate risks (e.g., Eisenhardt and Schoonhoven, 1996), and improve innovation capability (e.g., Easterby-Smith and Prieto, 2008). As several of the benefits are knowledge related, inter-organizational KT is often required to access the benefits (Galati and Bigliardi, 2019). Based on Argote and Ingram (2000), Inkpen and Tsang (2005, p. 149) defined KT in a network as a “process through which one network member is affected by the experience of another.”

This view, also adopted in the current article, emphasizes the impact that knowledge has on the recipient, meaning that, for example, the recipient’s exposure to the new knowledge is not sufficient for knowledge transfer.

Considering the aforementioned potential benefits resulting from collaboration and the significance of KT in the collaboration, it is logical that several academic studies have concentrated on the identification and analysis of the conditions that enable and facilitate the KT. Various theoretical concepts have been formed to structure these findings and to deepen the understanding. Absorptive capacity, first introduced by Cohen and Levinthal (1990), studies a firm’s ability to recognize and understand new external knowledge, assimilate what is valuable, and apply the assimilated knowledge (Lane et al., 2006). Social embeddedness, in the context of inter-firm relationships, reflects the number of social attachments in commercial relations (Uzzi and Lancaster, 2003). The higher the level of embeddedness, the more the transfer of private knowledge and exploratory learning will occur in the relationships (Uzzi and Lancaster, 2003; Dhanaraj et al., 2004). Often considered as having relational and structural dimensions, the concept of social embeddedness is closely related to the concept of social capital, which is discussed in detail in Section 2. Yet another concept used to explain KT fluency is

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<https://doi.org/10.1016/j.technovation.2022.102475>

Received 12 October 2020; Received in revised form 15 October 2021; Accepted 23 January 2022

Available online 4 February 2022

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knowledge stickiness; the stickier the knowledge, the more effort is needed for KT (von Hippel, 1994; Andersen, 1999). In intra-firm KT matters, such as lack of absorptive capacity, causal ambiguity and the arduousness of the relationship are sources of stickiness (Szulanski, 1996). Also, various distances between firms can affect the success of the KT. In relational contexts, the “distances” cover, for example, differences in knowledge base and in norms between the knowledge donor and recipient (Cummings and Tseng, 2003). From the opposite perspective, the similarity of firms has been used to analyze KT conditions (e.g., cultural similarity in Ibert and Müller, 2015).

My motivation to study the inter-firm KT and KT conditions in R&D project networks comes mainly from two sources. First, the existing literature does not seem to directly cover the phenomenon, that is, inter-firm KT, in the presented context, that is, R&D project networks receiving public funding. The premise behind the study is that the conditions enabling or facilitating KT in a certain network or project type may not do so in others or may have lesser significance. This view is supported by Inkpen and Tsang (2005), who studied social capital circumstances facilitating inter-firm KT in industrial districts, strategic alliances, and intra-corporate networks and found significant differences in the favorable conditions in various network types. Dvir et al. (1998) argued that project success factors are not universal and strongly depend on the type of the project. Easterby-Smith and Prieto (2008) identified from literature several differences between inter- and intra-organizational KT. In addition, in the comparison of the typical social capital characteristics of strategic alliances and R&D project networks, several differences were identified, indicating differences in the favorable KT conditions (Majuri and Lanz, 2018).

While studies of KT in the R&D project context do exist, they tend to focus on KT between firms and universities/research organizations (e.g., Beise and Stahl, 1999; Zellner, 2003; Mitton et al., 2007; Siegel et al., 2004; McDevitt et al., 2014; Rajalo and Vadi, 2017). On the other hand, in studies of inter-firm R&D collaboration, the project perspective is often missing, for example, in R&D alliances (e.g., Moverly et al., 1996; Lin et al., 2012), supply chains (e.g., Lawson and Potter, 2012), and industrial districts (e.g., Albino et al., 1999). The project network here means that the network is created for the project, unlike, for example, in strategic alliances in which the existing network can implement R&D collaboration through projects. Project networks have a temporary nature and the network members often have no previous experience on collaborating together. The presence of these network characteristics can have fundamental effects on KT conditions, for example, on trust formation (Faems et al., 2007), and thus I consider that the existing literature on more stable networks may not adequately explain the KT dynamics in project networks. However, in some studies of R&D collaboration, the project and inter-firm perspectives are present, but they lack the KT focus and/or the project is not initiated by public funding (e.g., Mishra et al., 2015). Again, I consider public funding as a central deterrent to network collaboration. The funding opportunity can be the primary motivation for a firm to join the network. In addition, the projects can offer an efficient platform for firms to collaborate with research institutes and universities. This means that, unlike network types such as R&D alliances or joint R&D ventures, the firm’s motivation to join an R&D project network may be tangentially connected to the possibility of exchanging knowledge with other firms. To conclude, the concentration on creating insight into a relatively well-established phenomenon has some unique preliminary characteristics.

Consequently, the research questions can be formulated as follows:

To what extent does inter-firm KT occur in R&D project networks receiving public funding?

What network conditions, in this context, explain the inter-firm KT and how?

The role of social capital, one of the relevant network conditions recognized during the analysis, is studied in detail. Also, the benefits of

KT are outlined, as are several factors that are capable of limiting the inter-firm KT. In addition, the potential synergies of inter-firm collaboration are identified and their impact on KT is evaluated. The study provides enhancements to KT and collaboration literatures, especially the ones that study the effects of different collaboration conditions to KT in various network types.

The second source of motivation to examine this topic is the potential significance to society and business. I consider the R&D project networks to be a collaboration platform with unique characteristics, in which firms can apply valuable knowledge from each other beyond that offered by universities or research institutes. Creating insight into the inter-firm KT and on enabling conditions in this specific context may give policy makers and coordinators valuable knowledge for planning such funding instruments and on coordination methods that better support the inter-firm KT.

The article follows standard practices and recommendations (Gioia, 2019) concerning the structure of both qualitative and quantitative research. The remainder of the article is organized as follows: a review of social capital, the main theoretical perspective of the study, a section on the methodology, including a description of the real-life context of the study, the case data itself, a qualitative comparative analysis (QCA), a discussion of the QCA results together with case data, and finally, conclusions and limitations are presented.

## 2. Social capital

The use of the term “social capital” goes back to the beginning of the twentieth century and community studies; it gained greater attention among scholars of various disciplines in the 1980s and 1990s (Farr, 2004). Since then, a wide repertoire of conceptualizations and definitions of social capital has emerged, (for various definitions, see e.g., Bjørnskov and Sønderkov, 2013 or Adler and Kwon, 2002). Since systematic review of concept definitions is beyond the scope of this article, this section focuses on viewing approaches by some of the leading contributors to the concept’s definition. Although the seminal works by authors such as Pierre Bourdieu, James Coleman, and Robert Putnam were published decades ago, very recent research often builds on the social capital conceptualization of these authors.

In his widely acknowledged article in the American Journal of Sociology, Coleman (1988, p.101) described social capital as representing entities that “consist of some aspect of social structures” and “facilitate certain actions of actors.” Adler and Kwon (2002) identified three categories of social capital: internal, external, and hybrid. Based on these categories, they considered Coleman’s approach to represent the internal view as it focuses on the “structure of relations” (p. 20) and viewed social capital as an internal capital of a social network. Bourdieu (1986, p. 21), representing the external view of social capital (Ashforth and Mael, 1989), defined it as “an aggregate of the actual or potential resources which are linked to possession of a durable network of more or less institutionalized relationships of mutual acquaintance and recognition.” In Bourdieu’s approach, the main emphasis is on the relations that the individual actor has with other external actors (Ashforth and Mael, 1989). In comparing the approaches of Coleman and Bourdieu, Bourdieu’s approach is focused on outcomes on the individual level, and Coleman’s approach considers outcomes on the level of social networks (Adam and Rončević, 2003). However, the distinction between Coleman’s and Bourdieu’s views is somewhat nonspecific. Portes (1998) considered that both approaches focus on an individual’s relations with other individuals or groups, which would indicate that Coleman’s view should be allocated to the “external” category. This view is somewhat supported by Bjørnskov and Sønderkov (2013), who stated that social capital is an individual resource in both approaches, but more clearly so in Bourdieu’s approach.

Regarding the individual versus network perspectives, the approach of Robert Putnam is consistently considered to represent the view that social capital is a resource in a collective of people (e.g., Portes, 1998; de

Vaan et al., 2019; Bjørnskov and Sønderskov, 2013), and as such, it belongs to the “internal” category. According to Putnam (1995, p.2), social capital “refers to features of social organization such as networks, norms, and social trust that facilitate coordination and cooperation for mutual benefit.” It is noteworthy that this definition indicates that a feature is required to have a positive impact in the social organization in order to be counted as a part of social capital. Putnam later changed his view such that whether a certain feature is social capital or not, it is dependent on the characteristics of the feature (Bjørnskov and Sønderskov, 2013).

The hybrid approach does not emphasize external or internal perspectives regarding social capital (Adler and Kwon, 2002). Inkpen and Tsang (2005, p. 151) defined social capital as “the aggregate of resources embedded within, available through, and derived from the network of relationships possessed by an individual or organization.” This definition, slightly modified from the definition by Nahapiet and Ghoshal (1998), represents the hybrid approach. The aforementioned definition is used in this article for three main reasons. First, to understand social capital’s significance in the inter-firm KT in R&D project networks, it is not purposeful to exclude internal or external aspects of social capital from analysis, as both types can affect the KT. For example, the culture of openness can form within the network, which facilitates the KT, or lack of trust between individuals can form a barrier for KT. Second, defining whether a specific feature of social capital is primarily a resource of an individual, firm, or network can be difficult, if not impossible. In addition, they are interlinked and contribute to each other. Third, the approaches by Nahapiet and Ghoshal (1998), and Inkpen and Tsang (2005) have been effectively used in several studies similar to this one, that is, the instrumental value of social capital is viewed for the organization’s or network’s processes (e.g., Akhavan and Hosseini, 2016; Carey et al., 2011; van Dijk et al., 2016; Gooderham et al., 2011; Mäkelä and Brewster, 2009; Zheng et al., 2014).

Especially in the 1980s and 1990s, the research streams commonly considered two sources for social capital: the structure of the ties in the social network, and the nature of those ties (Adler and Kwon, 2002). The former represents the structural dimension, and the latter, the relational dimension of social capital as the division roots in Granovetter’s (1992) discussion on structural and relational embeddedness. A third dimension, cognitive social capital, was presented by Nahapiet and Ghoshal

(1998). The structural social capital illustrates the impersonal characteristics of social capital, especially the “pattern of connections between actors” (Nahapiet and Ghoshal, 1998, p. 244), or, as explained by Villena et al. (2011, p. 563), “structural capital rests on the existence of connections and their configurations within a social structure.” According to Nahapiet and Ghoshal (1998, p. 244), relational social capital refers to “assets created and leveraged through relationships” and explains an individual’s behavior through social motives. The cognitive social capital “is embodied in attributes like a shared code or a shared paradigm that facilitates a common understanding of collective goals and proper ways of acting in a social system” (Tsai and Ghoshal, 1998, p. 465). Eklinder-Frick et al. (2014) also proposed a three-dimensional model for analysis of social capital formation based on where the social capital is created; they identified socio-economic (e.g., regions), structural (e.g., networks), and actor-oriented (e.g., single firm) dimensions. In this article, especially, the structural dimension of the mentioned categories is emphasized. Also, the relevance of socio-economic sources of social capital are recognized, as the studied cases are all located in one country: Finland.

The dependencies and causalities between the dimensions of social capital have been considered in previous research (Fig. 1). Li et al. (2013) suggested that structural social capital supports the formation of relational and cognitive social capital. However, Tsai and Ghoshal (1998) did not find the causality between structural and cognitive capitals as significant. Additionally, cognitive social capital can positively affect relational social capital (Carey et al., 2011). However, the strength of causalities should be viewed with caution, due to the multifaceted interconnections between various features of social capital, and because the existence of a certain dimension is likely to require the presence of the other two forms of social capital.

The concept of social capital is not without criticism. The fundamental question, raised by Bjørnskov and Sønderskov (2013), is whether social capital is a good concept or not. The difficulty here is that social capital is conceptualized and defined in many ways, so that a “goodness” identified in one conceptualization might not be accurate for another. On the other hand, if the conceptualization is formed by identification of a common nominator(s) of various approaches, the definition becomes very generic, which in turn, potentially weakens social capital’s heuristic value. This is a concern presented by Portes (1998). Bjørnskov and

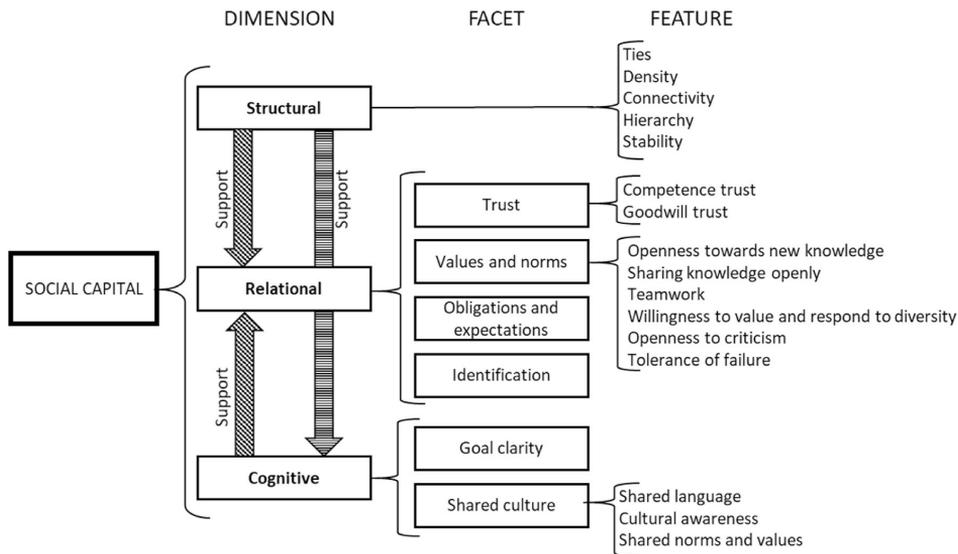


Fig. 1. Social capital framework used in the study.

Sønderskov (2013) identified major challenges related to social capital as a concept. In their evaluation on the usage of Putnam's (1995) conceptualization, they concluded that social capital should be defined as "several distinct phenomena or as phenomena that already have been conceptualized under other labels. (p. 1225)". The latter notion was also emphasized by Portes (1998).

The causalities related to social capital can be complex. For example, some authors consider trust or quality of governance as sources of social capital, while others consider them manifestations of social capital (Adam and Rončević, 2003). Coleman's approach was criticized by Portes (1998) for not making a clear differentiation between resources accessible through social capital and the social capital itself. Overall, social capital can enhance the performance, but increased social capital can also be a consequence of better performance (Li et al., 2013). In addition, social capital is not always a beneficial resource (Coleman, 1990). The objectives of a social network can be undesirable, so as network activities are facilitated by social capital, the network has an increased opportunity to achieve its negative goals. Naturally, it can be argued, that in this scenario, the negativity depends on perspective. For example, a criminal group might consider some outcomes positive while from society's perspective, the outcomes are negative. A second aspect is that, despite the fact that social capital is often considered to have facilitative effects on network, it can also have the opposite influence. de Vaan et al. (2019) found that social capital can restrict the growth of a new industry. Pillai et al. (2017) identified several negative consequences that a high level of social capital can promote, for example, group-thinking, inhibition of learning, and commitment to "failing courses of action" (p. 109). The positive impact of social capital can also be lower than expected; for example, Kianto and Waajakoski (2010) found that social capital had only a meager effect on firms' growth when measured in South Karelia, Finland.

The following sub-sections present facets and features recognized for this study in the structural, relational, and cognitive dimensions of social capital (Fig. 1). Tables are presented in which features are operationalized into question form. The questions are mostly based on a combination of the literature presented in sub-sections and on the author's own conclusions. In cases where the question is derived from a single source, the source is mentioned alongside the question. For definitions of dimensions, features, and facets of social capital, the author depended mostly on the articles of Nahapiet and Ghoshal (1998) and Inkpen and Tsang (2005). Although they are not very recent literature, they were considered still valid. During the last decade, these works have played a central role in defining the "ingredients" of social capital in several studies, for example, in Villena et al. (2011), Gooderham et al. (2011), Carey et al. (2011), Ansari et al. (2012), Li et al. (2013), Zheng et al. (2014), Makkonen and Virtanen (2015), Akhavan and Hosseini (2016), van Dijk et al. (2016), and Theodoraki et al. (2018).

### 2.1. The structural dimension of social capital

Structural social capital illustrates the impersonal characteristics of social capital, especially the "pattern of connections between actors" (Nahapiet and Ghoshal, 1998, p. 244), or, as explained by Villena et al. (2011, p. 563), "structural capital rests on the existence of connections and their configurations within a social structure." Li et al. (2013) identified features such as ties, configuration, and density among people as the features of structural social capital, claiming that the scholars studying structural social capital have often considered it to be predictive of relative and cognitive capital. The concepts of structural holes (see, e.g., Burt, 2000) and centrality (Li et al., 2013) are often associated with structural social capital. In these concepts, individuals or firms may have a position in the network that connects otherwise weakly connected parts of the network together, thus gaining an individual or firm control over knowledge flow (Burt, 1992). To measure structural social capital in R&D teams, Akhavan and Hosseini (2016) evaluated the closeness of relationships, time spent in interactions, and frequency of

communication. To understand structural social capital, Kim et al. (2013) evaluated "the goodness" of relationships and awareness of the importance and availability of knowledge among network members. Drawing from Nahapiet and Ghoshal (1998) and Inkpen and Tsang (2005), the following features are included in the structural social capital in the current thesis: ties, density, connectivity, hierarchy, and stability. The features of structural social capital used in the present study are listed and defined in Table 1.

Network **ties** are the connections between the network members, and thus potentially allow individual network members to access knowledge and other resources held by other network members (Coleman, 1990; Nahapiet and Ghoshal, 1998). According to Rojas et al. (2011), personal and associational ties together form the basis of structural social capital. This aspect was included, at least partially, in an earlier study by Inkpen and Tsang (2005), who evaluated the nature of ties based on whether they were among individuals or firms. Both types of ties have the potential to strengthen the other. In R&D projects, the tie often forms first between firms and thereafter, forms among individuals as the cooperation continues. In addition, the individuals participating in the project planning are often different from the actual people working on the project.

The **density** of ties refers to the overall number of ties between network members compared to the number of possible ties (Grabher and Ibert, 2006). The feature **connectivity** is used here to refer to how well the ties cover the network. Although the density and connectivity are inter-related, the total number of ties may be high, making density high as well, but ties can be limited to certain parts of the network, making the connectivity low.

**Hierarchy** is often associated with formality, governance, centralized decision-making, and bureaucracy, and often has negative effects on social capital (Adler and Kwon, 2002; Gooderham et al., 2011; Grandori, 2001). Hierarchical governance can hinder the development of goodwill among colleagues (Gooderham et al., 2011), just as anti-authoritarian ideologies assume hierarchical structures often deemed to be "destructive" for the social capital in societies (Adler and Kwon, 2002, p. 28). On the other hand, formal institutions as representatives of hierarchical constructions are considered to facilitate the formation of social capital (Adler and Kwon, 2002). In addition, Williamson (1981) considered the hierarchical structure of a firm to reduce the costs of various types of transactions compared to non-hierarchical markets. In the current study, hierarchy implies the power and authority that the members might have towards other members. For example, in the case that the customer and supplier belong to the same R&D project network, the customer can have some authority over suppliers' R&D activities, especially if the suppliers' R&D intentions are related to this relationship.

Network **stability** refers to the extent to which changes in network memberships occur. Change may concern a new firm entering the network or one leaving the network. Also, changes in firm representatives reduce the networks' stability. In addition, instability can occur within the network when new ties are formed and old ones are abandoned (Beckman et al., 2004). Stability of the network leads to the continuity of social relationships, which in turn, promotes the formation of other features of social capital, such as trust (Adler and Kwon, 2002) and shared norms.

**Table 1**  
Features of structural social capital, adapted from Inkpen and Tsang (2005) and Nahapiet and Ghoshal (1998).

Feature	Addressing question
Ties	On which ties is the connection based—those among people or firms?
Density	What is the number of inter-firm ties in the network compared to the number of possible ties?
Connectivity	To what extent do the ties cover the network?
Hierarchy	What is the level of hierarchical relationships in the network?
Stability	To what extent do changes occur in network memberships?

## 2.2. The relational dimension of social capital

The relational dimension of social capital is related to personal relationships among people and refers to “assets created and leveraged through relationships” (Nahapiet and Ghoshal, 1998). This dimension explains individuals’ behavior through social motives (Nahapiet and Ghoshal, 1998). Further, relational social capital can explain network activities in a situation when “hard facts” appear to be contradictory. For example, two individuals from different organizations can continue to collaborate even though the collaboration has not produced anything apparently beneficial. Based on a meta-analysis of 75 journal articles, van Wijk et al. (2008) considered relational social capital to be the most important of the three dimensions of social capital for inter- and intra-organizational KT. Carey et al. (2011) found that cognitive and structural social capital positively influence the formation of relational social capital.

When scholars evaluate relational social capital, trust is almost always included. Features such as norms (e.g., Theodoraki et al., 2018; van Dijk et al., 2016; Sutanto, 2013; Weber and Weber, 2007), obligations (e.g., Theodoraki et al., 2018), expectations (e.g., Theodoraki et al., 2018), and identification (e.g., Theodoraki et al., 2018; van Dijk et al., 2016; Akhavan and Hosseini, 2016; Sutanto, 2013) are also often considered to be part of relational social capital. The aforementioned features of social capital, especially norms and trust, are often referred to in governance studies in which the relationship between formal and informal governance mechanisms is considered (e.g., Poppo and Zenger, 2002; Cannon et al., 2000; Carson et al., 2017). Slightly modified from Nahapiet and Ghoshal (1998), the following features of relational social capital are included in the current thesis: trust, values and norms, obligations and expectations, and identification. Table 2 lists and defines the features of relational social capital used in this study.

**Table 2**

The relational dimension of social capital (facets from Nahapiet and Ghoshal, 1998; features of norms from Nahapiet and Ghoshal, 1998; features of trust from Ireland and Webb, 2007).

Facet	Feature	Defining question
Trust	Competence trust	Do the network members trust in each other’s competences, and to what extent?
	Goodwill trust	Do the network members trust that other members have goodwill toward them, and to what extent?
Values and norms	Openness toward new knowledge	How willing are the network members to acquire and exploit new knowledge from other members? ( Hoegl and Gemuenden, 2001)
	Sharing knowledge openly	How willing are the network members to share their knowledge?
	Teamwork	To what extent do members work on common tasks? (Hoegl and Gemuenden, 2001)
	Willingness to value and respond to diversity	How willing are the members to value and respond to diversity?
	Openness to criticism	How willing and able are members to receive and exploit critical feedback?
Obligations and expectations	Tolerance of failure	How constructive are the attitudes toward failures?
		How committed are the members to undertake certain activities? ( Nahapiet and Ghoshal, 1998) Is this commitment expected by other members?
Identification		To what extent do the individuals in the network identify themselves with other people in the same network? (Nahapiet and Ghoshal, 1998)

**Trust** is one of the most, if not the most, studied areas of social capital; its beneficial effects on collaboration are supported by multiple empirical studies (Krishnan et al., 2006). For example, trust facilitates openness (Krishnan et al., 2006) and information flows (Zand, 1972), and reduces conflicts (Simons and Peterson, 2000). Typical ways to define trust are to approach it from the perspective of expectations (e.g., Simons and Peterson, 2000; Krishnan et al., 2006), or from reliance (e.g., Curral and Inkpen, 2002) on others. This implies that a trustor expects certain behavior from a trustee or relies on the trustee to behave in a certain manner. This behavior can also be excluding—that is, the trustor expects or relies on the expectation that the trustee will not behave in a certain manner e.g. opportunistically.

McAllister (1995) suggested the categorization of trust into two dimensions: cognitive and affective. The cognitive dimension represents analytical and rational trust, which includes issues such as reliability and capabilities (Schoorman et al., 2007); in contrast, affective trust is more personal and, thus, emotion-based, and focuses on whether the trustor believes that the trustee is actually concerned with the well-being of the trustor (Dirks and Ferrin, 2002). This study divides the trust into two categories used by Ireland and Webb (2007): competence trust and goodwill trust. The former is associated with the analytical and rational trust and the latter with the affective trust. Goodwill trust exists when the trustor believes that the trustee is concerned with the well-being of the trustor (Dirks and Ferrin, 2002) and will not behave opportunistically. Competence trust, or cognitive trust, refers to trust in the capabilities and reliability of the trustee (Schoorman et al., 2007).

Based on various sources in the literature, Fehr and Fischbacher (2004, p.185) defined social norms as “standards of behavior that are based on widely shared beliefs how individual group members ought to behave in a given situation.” Norms can provide support or rewards and can prevent negative activities (Coleman, 1988). In the research, the focus is often on norms that have a tendency to facilitate the intra-network KT; however, they can also be a force that isolates the network from the environment and, depending on the nature of the norms, can have negative effects on sharing knowledge (Nahapiet and Ghoshal, 1998).

As norms represent context specific behavior, values are more generic by their nature and create guidelines for personal behavior (Bardi and Schwartz, 2003). Schwartz and Bilsky (1987, p.551) identified from literature following features being common for definitions of concept of value: “values are concepts or beliefs about desirable end states or behaviors, that transcend specific situations, guide selection or evaluation of behavior and events, and are ordered by relative importance.” It is noteworthy, that, although norms often manifest peoples’ values, an individual may act according to group’s norms that oppose his/her own values (Bardi and Schwartz, 2003).

This study adopts the norms identified by Nahapiet and Ghoshal (1998): openness towards new knowledge, sharing knowledge openly, teamwork, willingness to value and respond to diversity, openness to criticism, and tolerance of failure. However, instead of norms, they are titled as ‘values and norms’ for two reasons. First, the borderline between values and norms is not always self-evident, e.g. values can be considered as “concepts or beliefs of desirable behaviors” (see previous paragraph) and norms as standards of behavior. Based on the research data in present study, it would be difficult, if not impossible, to evaluate whether certain behavior was “desirable” or “standard”. Second, several of the listed features could be considered as values. However, the author wishes to connect this article to the previous line of research on KT conditions in networks in which notion of norms is typically used to describe beforementioned features. For this reason, the “norms” is included into the facet name.

Network members may not be open to new knowledge, thereby implying that they are not willing to acquire and exploit new knowledge offered by other members. This may be due to self-sufficiency, the so called not-invented-here syndrome, or the limited ability to benefit from available knowledge (as in absorptive capacity); however, the latter

example is only slightly norm-related. As social capital can limit the openness towards new knowledge (Woolcock, 1998), it is possible that the social capital within an individual firm of the R&D project network may limit the firm representative's openness towards available knowledge in the network. Willingness to share knowledge openly may depend on the need to protect knowledge for competitive reasons. Nevertheless, the members may not share the knowledge with others for a simple reason that it is not the norm of cooperation. Moreover, personal reasons, such as shyness, may prevent sharing the knowledge at social events.

Hoegl and Gemuenden (2001) identified six factors that support teamwork performance: communication, coordination, balance of member contributions, mutual support, effort, and cohesion. These facets are used as a manifestation of teamwork, that is, their presence in collaboration is a sign of teamwork. For simplicity, teamwork is defined here as the extent to which members work together on common tasks (Hoegl and Gemuenden, 2001).

Diversity of network members can create richness in the network because it enhances creativity and innovativeness, as more diverse ideas are brought into discussions. However, diversity may also create challenges, since it may cause inefficiency to interaction within the network (Reagans and Zuckerman, 2001); for example, more effort may be required for the "translation" of terminology. When members appreciate diversity, they are more willing to invest the required effort to overcome diversity-related challenges, which also encourages the sharing of expertise in various disciplines (Boland and Tenkasi, 1995).

Networks offer members the possibility to obtain feedback for their plans, actions, and results. Positive feedback can strengthen the belief in one's own activities and encourage the continuation "in the chosen path." Naturally, receiving positive feedback is emotionally easy. However, more critical feedback may raise an emotional barrier that disables the constructive use of feedback; thus, openness towards critical feedback is necessary. Intolerance towards criticism may cause an individual to seek feedback, for example, for an idea from familiar actors who easily agree with the individual, which in turn, might not be optimal for the further development of the idea (Granovetter, 2005).

In particular, regarding the collaborative platforms aiming to create something new, it is important that at least a certain number of failures is tolerated. Intolerance towards failures may impair willingness to experiment. In addition, it can lead to hiding failures, which slows the overall learning in the network or can make it more difficult to achieve a network's mutual objectives; for example, sharing failures in the network may help other members to avoid making the same mistakes.

According to Nahapiet and Ghoshal (1998, p. 255), "obligations represent commitment or duty to undertake some activity in the future." **Expectations** are present when people anticipate certain actions from others. In the present study the feature of obligations and expectations is used to refer to a "credit slip" between certain people (see Coleman, 1988; Nahapiet and Ghoshal 1998), not prevailing norms of a group or a network, i.e. when certain behavior is generally expected. In addition, the obligations and expectations based on formal reasons, such as project plans or contracts, are not studied. The credit slip means that when a network member A does something beneficial for a network member B, the favor creates expectation for A that the B will return the favor in the future. Also, the B feels obligated returning the favor at some point. The confidence towards B returning the favor to A is an essential element in building the trust between the members (Zaheer et al., 1998).

According to Ashforth and Mael (1989, p.20), social **identification** is a "perception of oneness with a group of persons" and it "leads to activities that are congruent with the identity." Nahapiet and Ghoshal (1998) suggested that social identification not only strengthens the expectations toward the potential value of knowledge created in the network, but also the motivation of individuals to support knowledge creation by sharing the knowledge. This identification can also be referred to as a "we-feeling" or experience of community (Vaisey, 2007; Kwon and Adler, 2014). Zhao et al. (2012, p. 585) found that a sense of

belonging increases "intentions to get and share experiences/knowledge" in virtual communities. The finding is relevant also in context of the current study, as several projects used internet-based platforms for knowledge-sharing.

### 2.3. The cognitive dimension of social capital

Based on Nahapiet and Ghoshal (1998), Inkpen and Tsang (2005, p. 153) defined the cognitive dimension of social capital as "resources providing shared meaning and understanding between the network members." Tsai and Ghoshal (1998, p. 465) explained cognitive social capital as being "embodied in attributes like a shared code or a shared paradigm that facilitates a common understanding of collective goals and proper ways of acting in a social system." Carey et al. (2011) measured the amount of cognitive social capital by evaluating the extent to which network members share values, goals, ambitions, and visions. Additionally, as part of cognitive social capital, Carey et al. (2011) measured how often the parties agreed on what is in the best interest of the relationship. A shared language is also often considered a central feature of cognitive social capital (e.g., van Dijk et al., 2016; Wasko and Faraj, 2005; Theodoraki et al., 2018), which includes features such as shared narratives (e.g., Theodoraki et al., 2018) and codes (Ansari et al., 2012). In order to categorize the features of the cognitive dimension, this study adopted from Inkpen and Tsang (2005) and Nahapiet and Ghoshal (1998), and used facets of goal clarity and shared culture. For definitions of cognitive social capital features used in the present see Table 3.

**Clear goals** can prevent conflicts between the members by facilitating various negotiations (Inkpen and Tsang, 2005). Clear goals can increase members' commitment because these types of goals describe what to commit to and provide guidelines on how to contribute to network activities. When goals are clearly stated on a member level, the visibility within the network is increased, and members can have more accurate expectations of each other's intentions (Inkpen and Tsang, 2005; Das and Teng, 1998). At least two reasons can be identified that make goals unclear in the context of the present study, and thereby cause challenges for collaboration. First, the vocabulary and expression can be complicated and/or ambiguous. This may lead to a situation in which network members begin to create their individual goals and neglect the network's objectives. Second, the goals may be defined so broadly that required actions are difficult to identify.

O'Reilly et al. (1991, p. 491) stated, "Typically, researchers have agreed that culture can be thought of as a set of cognitions shared by members of a social unit." Inkpen and Tsang (2005, p.153) considered **shared culture** as "the degree to which norms and behavior govern relationships." This informal aspect of governance exists in parallel with formal governance mechanisms (Hoetker and Mellewigt, 2009). Poppo and Zenger (2002) considered that both forms of governance complement each other. In the current study, the features of shared language, cultural awareness, and shared norms and values are included in the facet of shared culture.

Shared language means that members have a shared understanding

**Table 3**  
The cognitive dimension of social capital (facets and features adapted from Inkpen and Tsang, 2005).

Facet	Feature	Defining question
Shared culture	Goal clarity	How clearly are the network goals understood?
	Shared language	What is the network members' ability to understand one another's expressions in a similar manner?
	Shared norms and values	To what extent do members have similar social norms and values?
	Cultural awareness	How able are the members to understand different organizational cultures?

of the meaning of the used language. Differences may occur because of, for example, different career and educational backgrounds. The words and language start gaining more specific meanings as the network members communicate together and form shared narratives for expression (Boland and Tenkasi, 1995; Nahapiet and Ghoshal, 1998). As shared narratives and metaphors facilitate the transfer of tacit knowledge (Nonaka, 1994, 2000), explicit knowledge can often be transferred through formal channels, such as documentation.

The norms included to the study are reviewed in section 2.2. as part of the relational social capital. However, from a quantitative perspective, it is also relevant to evaluate the extent to which the norms are shared in a social network, for example, their impact on network governance. Civic norms, when shared among network members, promote collaboration and mitigate misunderstandings (Kaasa, 2009), and shared values facilitate meaningful communication (Li, 2005). The shared norms can be considered expressions of shared values (O'Reilly et al., 1991). However, shared norms may also have negative effects on the network, as they may “create excessive expectations of obligatory behavior and may possibly result in problems of freeriding and unwillingness to experiment beyond the network” (Inkpen and Tsang, 2005, p. 153). The potential challenges coming from differing values and norms can be hindered by cultural (or intercultural) (Parkhe, 1991) awareness. Cultural awareness of a network implies the level of knowledge and understanding of cultures in different organizations (Buckley et al., 2006). A higher level of awareness enables network members to better anticipate other members' actions and it may alleviate conflicts by making somewhat questionable actions feel more understandable.

### 3. Methodology

To address the research questions, a two-fold research design was employed. Inductive and qualitative research design was used to create understanding regarding the extent of inter-firm KT in R&D project networks and for identification of the network conditions as being able to explain the realized KT. From the objective's perspective, this part of the study was explorative, which is a suitable approach, particularly when research aims to explore a specific phenomenon that is only partially understood (Kumar, 2011; Eisenhardt and Graebner, 2007). A set theoretic method, qualitative comparative analysis (QCA), was used to analyze the causalities between conditions and KT (outcome). The QCA results were further evaluated and discussed along with the in-depth data about the cases (Section 6). The use of QCA is explained in more detail in Section 5.

The research was conducted as a multiple case study. According to Eisenhardt and Graebner (2007), “case studies emphasize the rich, real-world context in which the phenomenon occurs (p. 25)” and “multiple cases also create more [compared to a single case] robust theory because the propositions are more deeply grounded in varied empirical evidence (p. 27)”. The research is contextualized, which adds the robustness of interpretation of the empirical data (Inkpen and Tsang, 2005). A qualitative method was selected over a quantitative one because the former is more suitable for providing insight into complex social processes (Eisenhardt and Graebner, 2007), like KT in networks. Moreover, the goal was also to study “the rich, real-world context” in which KT occurs; thus, case study was an appropriate method.

#### 3.1. Overview of cases

The empirical data for the study was collected from seven collaborative R&D projects. Each project was considered as a single case. The projects were partially funded by Finland's largest public funding agency (PFA) for research, development, and innovation. In most cases, the funding shares ranged from 25 to 30 percent. The remainder was covered by firms' own funding. All projects had strong research institute and/or university involvement. However, project coordination varied. In certain cases, project coordination was shared between a firm and a

university/research institute(s), while in some cases a university was solely responsible for the coordination. In addition, in Cases 1 and 2, there was also a specific coordinator from outside the actual consortium who focused on administrative tasks. In Cases 1, 2, and 3, public funding was applied straight from PFA. In Cases 4–7, the PFA funding came through programs that were governed by centers for science, technology, and innovation (SHOKs). In Case 4, the R&D actions were taken under the garb of the program and a project-level structure did not exist. The project volumes ranged from hundreds of thousands to millions of euros. The program budgets were tens of millions of euros. The project durations ranged from two to five years. The real-world setting of the study is illustrated in Fig. 2.

The case firms were a good representation of the structure of Finnish business. Finland is a high-cost country in which the industry focuses on producing high value-added investment goods to other businesses. The machine-building sector includes large brand owners that have mainly outsourced their production to national and international supply chains. In Finland, these sub-contractors are mostly small and medium-sized enterprises (SMEs). Further, the information and communication technology (ICT) sector includes a large diversity of companies ranging from gaming and cyber security to telecommunications. A characteristic feature of Finnish business life is that people in the same business sector often know each other or are at least aware of each other's existence.

#### 3.2. Data collection

The data was collected through 18 face-to-face interviews, with one interview in each company. All participants were the primary representatives of their companies in the projects. The interviewees were informed in advance only of the subject of the interview and were asked not to prepare for it in any specific manner. I believe this supported the authenticity of the received information, as the interviewees had to react to questions spontaneously. The interviews took place between late 2015 and early 2017.

The interviews had structured and semi-structured sections. In the structured section, the interviewees were asked to phase the projects according to the subobjectives or milestones of the project. These phases were then fed into an Excel sheet and were individually discussed during the interviews. This appeared to support the level of detail of discussions, as it helped interviewees remember phase-specific events. The planning phase of the project was also included in the project phases. Events that took place after the project (funding) ended were occasionally discussed and mentioned in the following sections, but these were not systematically included in the study. The structured portion was conducted at the beginning of each interview. The semi-structured interview protocol is presented in Appendix A. Interviews were recorded and yielded 30 h of material. The interview recordings were transcribed verbatim, although non-verbal sounds were excluded from the transcriptions.

#### 3.3. Analysis

Transcriptions were reviewed three times and several summaries were created in order to identify the events involved in KT and related network circumstances. Converting the interview data into more analyzable form involved two basic steps: first, creating summaries of the interviews of each informant and, second, conducting case-level summaries. During the previous activities network conditions, certain patterns and themes affecting the KT began to emerge. Social capital was recognized at this point as an appropriate theoretical framework to structure the case findings. Also, other common nominators, such as motivation towards collaboration, were identified to potentially affect the collaboration and KT. The case data is structured according to these nominators in Section 5. The conducted QCA in combination with the in-depth analysis of the cases not only explains how the identified conditions affect the KT, but also illustrates the explanatory strength of the

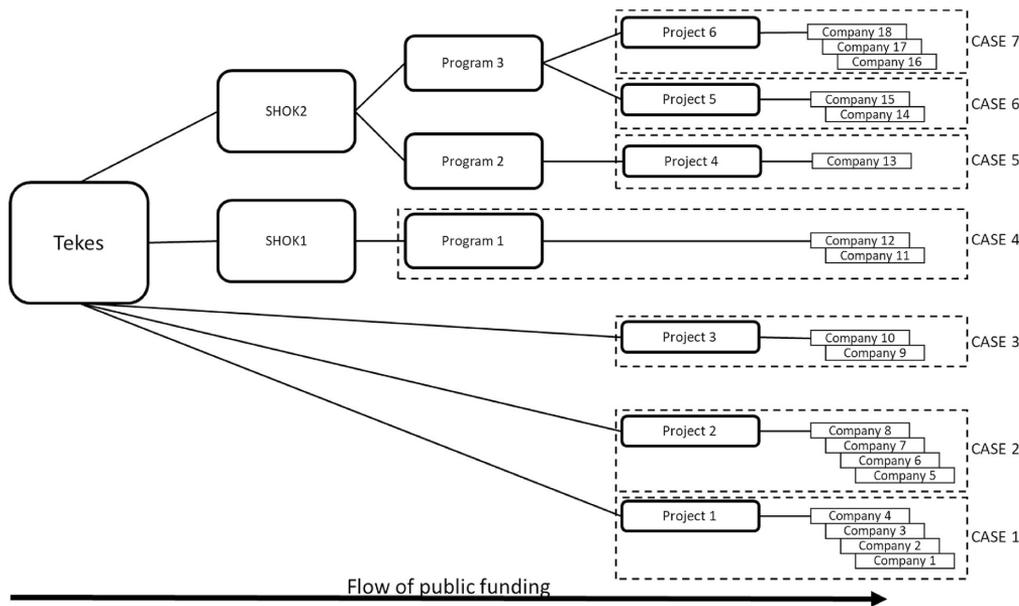


Fig. 2. Real-world setting of the research.

conditions, that is, whether or not the relevant conditions were identified.

Apart from Case 5, the case summaries were constructed from interviews with two or more informants. In situations when the comments of two or more informants on the same case and subject differed or were contradictory, the comments were not included in the summaries, as there was no opportunity to evaluate which view was appropriate or closest to what happened and why.

4. Cases

The following categories for case data were recognized during the construction of the several summaries of the transcribed interviews: manifestations of structural social capital, manifestations of relational social capital, manifestations of cognitive social capital, KT impact, KT barriers and limiting factors, collaboration platforms, and potential synergies. Additional case info is provided at the end of each case description. The description of each case begins with consortium representation including the identification of informants.

In all cases, the interaction between individuals and between firms occurred in the formal project meetings, and thus activities related to this aspect of structural social capital are mentioned only if they also occurred outside of the formal project meetings. In addition, the networks were generally very stable, so only occurrences of instabilities are referenced in descriptions. Regarding the goal clarity feature of social capital, all projects had goals explicitly defined in the project plans and thus this aspect is not included in case descriptions. In situations wherein the case data does not include information pertinent to a particular case data category, the category is excluded from the case description.

4.1. Case 1

**Consortium and informants:** The consortium comprised six manufacturing companies from the piece goods industry: three large end product manufacturers (EPM) and three sub-contractors (SMEs), as well as two research organizations and a coordinator, whose main duty it was

to coordinate reporting to the funding agency. Four interviews were conducted: two in SMEs (C1, C2) and two at large end product manufacturers (C3, C4).

**Manifestations of structural social capital:** C1 was a supplier of C3. However, the companies did not collaborate beyond the steering group meetings.

**Manifestations of relational social capital:** The participant from C4 felt that they were able to share knowledge openly in the steering group meetings, and the general atmosphere was good. The informant explained their ability to share knowledge openly due to the absence of competitors.

**KT barriers and limiting factors:** The customer of C2 participated in the planning phase of the project but was excluded from the actual project. This caused C2 to feel like an outsider in the project. The informant from C4 explained that all members appeared to have highly scoped individual R&D goals, which weakened opportunities to change truly beneficial knowledge. The participant from C3 explained the limited communication as being due to inadequate resource allocation from both qualitative and quantitative perspectives. The shared knowledge was characterized as “nice to know” and “interesting,” but it was still not considered to be particularly useful. The motivation towards the shared knowledge was low due to highly scoped company-specific R&D goals, which were pursued by collaborating closely with the two research organizations in the consortium.

**Collaboration platforms:** Collaboration was limited to the formal steering group meetings.

**Other:** The C1 delivered materials to a research institute for testing. The testing results were beneficial for both C1 and C3.

4.2. Case 2

**Consortium and informants:** The consortium comprised four SMEs from various roles in logistics, two research organizations and a coordinator whose main duty was to coordinate reporting to the funding agency. Four interviews were conducted with the firm representatives (C5, C6, C7, and C8).

**KT barriers and limiting factors:** The participant from C5 reported

having a close relationship and shared vision regarding the collaboration with a representative of C6. However, this person left C6 in the planning phase, and a new representative had a different intention regarding project goals. C5 and C6 stated that the R&D objectives of individual firms were close, but not sufficiently close to facilitate collaboration. C5, C6, and C7 criticized the planning phase in terms of being unable to involve firms with synergic objectives into the project. The collaboration with the research organizations was close, and it satisfied the majority of the needs concerning external knowledge. C8 also considered that time limitations reduced the possibility to identify common interests with other firms.

**Collaboration platforms:** Collaboration was limited to formal steering group meetings.

**Other:** The project scope was relatively loose. A firm that was considered by C5 and C6 as a potential partner left the consortium during the planning phase.

#### 4.3. Case 3

**Consortium and informants:** The consortium comprised five companies—three SMEs selling products and services mainly for consumers, and two large logistics companies. The consortium also included three research organizations and a coordinator whose main duty was to organize reporting to the funding agency. Two interviews were executed: one in a large firm (C9) and one in an SME (C10).

**Manifestations of structural social capital:** In the latter phases of the project, a few firm members became passive, and the active members, C9 and C10, and another large firm, formed the core group of the project. In this core group, the active collaboration between individuals was maintained and the firms took collaborative actions. The collaboration between participants from C9 and C10 continued even after the project ended, and the participant from C10 changed employers.

**Manifestations of relational social capital:** The participant from C10 was motivated to learn from others and valued highly the open and innovative atmosphere of collaboration in the core group. According to the participant, even “stupid ideas were tolerated.” The informant emphasized the importance of including the right people in collaboration and felt that the core group formed a team. C10 considered the core group members had clear expectations toward each other, which in turn added motivation for independent development work, as the expectations of other members were not to be disappointed. The participant from C9 emphasized the same characteristics of collaboration within the core group. In addition, he appreciated the diversity of the core group and considered the absence of competitors increased trust among project members. The overall atmosphere in the core group of the consortium was characterized as innovative by both informants.

**Manifestations of cognitive social capital:** The participant from C10 felt that the clear roles of each firm in the planned new business model brought clarity to the expectations that the firms had toward each other. The core group was able to set clear goals for collaboration outside of the project scope. In addition, the informant of C10 expressed that different operational cultures created a learning opportunity for them.

**KT impact:** Co-creation of two initiatives beyond the project scope. The participant from C10, the CEO of the company, particularly appreciated the possibility of learning about matters related to organizational culture from C9 and also believed that after the project they would be “a better partner” in their future R&D ventures. The participant from C9 also considered that they were able to gain plenty of constructive feedback in the inter-firm meetings.

**KT barriers and limiting factors:** Some consortium members outside of the core group were passive, and reasons for this are not known.

**Collaboration platforms:** In addition to the steering group meetings, the members of the core group organized informal meetings in which several collaborative ideas were generated.

**Potential synergies:** The project aimed to create a synergic business model in which all members played individual roles.

**Other:** In the planning phase of the project, the straight interaction between companies was weak. Nevertheless, the project coordinator and a research organization that managed the planning phase carefully included the intentions of individual companies in the project plan. In the beginning of the execution phase, the collaboration among the companies began strongly, as, together, the companies planned a survey that was implemented by research organizations. The results of the survey were analyzed together.

#### 4.4. Case 4

**Consortium and informants:** The consortium comprised tens of companies of different sizes from the same field/industry, with an annual program budget of over 20 million euros. Two interviews were conducted in large companies (C11, C12).

**Manifestations of structural social capital:** The program was a continuation from an earlier program and, thus, most of the companies had prior experiences with collaboration with each other. The ties between firms were supported by sophisticated digital platforms in which individual results were actively shared.

**Manifestations of relational social capital:** Both participants emphasized the high degree of openness in sharing results among the consortium members. The consortium included several competitors. However, this did not restrict the openness, since the program topics were such that open sharing of knowledge was not considered as a competitive risk. The participant from C12 valued the atmosphere of inter-firm interaction and explained that they “were able to agree on several things that are typically extremely difficult to agree on.” Further, the informant felt that the trust and interpersonal knowledge played a crucial role in the firms’ willingness to share their R&D results so openly.

**Manifestations of cognitive social capital:** The participant from C12 had experience with issues related to intra-firm knowledge sharing and believed that this helped adjust the firm’s operations as part of the open knowledge-sharing culture of the program. In addition, the participant appreciated that C11 provided some examples to the entire consortium by sharing knowledge openly in the early phases of the project. The program scope was loose but still clearly defined. More concrete goals were defined annually during the four years the program lasted. The most significant results were shared publicly. The participant from C11 valued the system in which the concrete program goals were defined for 1 year at a time, since it enabled the program to adjust for changing business circumstances. The high frequency of meetings and workshops improved the goal orientation inside the network.

**KT impact:** C12 involved over 10% of their personnel in the workshops and meetings related to the program. This enabled people to present their ideas to others and obtain feedback. The participant felt that this increased people’s confidence in their ideas. In addition, it facilitated the participant’s role as a contact person in intra-firm communication on program-related matters.

**KT barriers and limiting factors:** The participant from C11 was the coordinator of the program and a very active member in the consortium. Despite the active communication with other firms, the participant considered that the actual learning occurred in the collaborations with research organizations.

**Collaboration platforms:** The program used advanced digital platforms for communication and for sharing the results of individual firms. The willingness to utilize these platforms was also characterized as being good. The entire consortium had quarterly meetings and regular workshops. The participation level was high in meetings and in workshops. The participant from C11 appreciated the frequent program meetings since it helped to coordinate member activities.

**Potential synergies:** The firms collaborated yearly to identify appropriate R&D goals for the entire network.

#### 4.5. Case 5

**Consortium and informants:** The consortium was comprised of eight large firms ranging from those in machine-building to ICT industries. The project was part of a small program with one other project. One interview was conducted in a large end product manufacturer (C13).

**Manifestations of structural social capital:** The participant appreciated the possibility of building personal connections with people who work in similar international companies. Although these personal connections were not actively exploited during the project, the informant made several connections with these people after the completion of the project.

**Manifestations of relational social capital:** The participant expressed that the absence of competitors in the consortium enabled them to share their results more openly. In addition, the participant stated that their company rarely engages in projects in which their competitors are present.

**KT impact:** The informant found steering group meetings to be beneficial, because they enabled the obtaining of confirmation of development actions taken and planned by C13. The participant expressed that the ICT companies, which were potential software suppliers for the rest of the consortium, learned about the business needs of C13 and were, thus, able to better serve them in the future.

**KT barriers and limiting factors:** The project-level scope was relatively loose, and individual companies focused on their individual R&D goals and on collaboration with the research institutes.

**Collaboration platforms:** C13's interaction with other firms was limited to project meetings, which were held three to four times a year.

#### 4.6. Case 6

**Consortium and informants:** This consortium was comprised of four large companies from the machine-building industry and three SMEs from ICT industries. The project was part of a large program with five other projects and tens of other companies. Two interviews were conducted in large end product manufacturers (C14, C15).

**Manifestations of relational social capital:** The participant from C15 expressed that the atmosphere had been good in the beginning of the project and had improved as the project continued and people became more familiar with each other. The participant from C14 considered the atmosphere of the project positive and open, and that the different business backgrounds of the firm representatives were appreciated.

**Manifestations of cognitive social capital:** The participant from C15 had active collaboration with ICT companies. In the beginning of these discussions, they defined the necessary terminology together. The participant from C15 stated that they were able to initiate cooperation at the beginning of the new project because they basically continued from where the previous project ended, and people had formed shared methods of working with each other.

**KT impact:** In the final stages of the project, the participant from C15 found it valuable that they were able to obtain feedback and confirmation from the consortium regarding their technological choices. The participant found that discussion with one of the large machine-building firms was beneficial, as it helped them consider their R&D work from a different perspective.

**KT barriers and limiting factors:** The participant from C14 explained that the project was a continuation of previous R&D work in which they obtained good results and come close to their desired final outcomes. This project was mostly considered an instrument to finance the last steps of R&D. The participant was aware that their R&D goals were similar to those of two other large companies and that there could have been potential benefits in exchanging ideas. However, the participant was unsure why this did not happen, but mainly attributes lack of time and the participant's own passivity as the explanation. The original

project budget was reduced and, thus, the project duration was shortened. The participant from C15 believed that this had a negative effect on the KT between firms, since in the final phases of the project the firms would have had more concrete and, thus, more appealing results to share.

**Collaboration platforms:** Members had steering group meeting three to four times a year. The participant from C15 had several discussions with ICT companies outside of formal project meetings. For C14, the interaction with other firms was limited to steering group meetings.

**Potential synergies:** C15 was a potential customer for ICT companies and the business approach streamlined the R&D discussions between C15 and the ICT companies. C14 considered their R&D goals to be similar to those of two other large companies.

**Other:** Both participants felt that the planning phase of the project was somewhat problematic, since the consortium was formed from a group of companies that were originally supposed to have three separate projects. In addition, there was uncertainty regarding whether the project would begin at all. For these two reasons, the project plan became loosely defined, which in turn slowed down the project execution at the outset. During the planning phase, a few large firms left the project, but during the execution phase, the consortium was stable. C15, along with a few other firms, began a new R&D project after the existing project was completed. The participant from C15 also felt that motivation towards knowledge exchange would be higher in networks created from value chains rather than horizontal networks, as in this project.

#### 4.7. Case 7

**Consortium and informants:** The consortium was comprised of five large companies of which four were in the machine building industry and one was in the subcontracting business. Included were two SMEs, one in software and one in the subcontracting business, and two research organizations. The project was part of a large program with five other projects and tens of other companies. Two interviews in large machine building end product manufactures (C16, C18) and one interview in a subcontracting business, SME (C17), were conducted. The participant from C18 was an industrial coordinator of the project and coordinated the project with a research coordinator from a university.

**Manifestations of structural social capital:** Three firms of the consortium formed a core group that included C16 and C18. Core group firms and individuals had a prior history of working together. In the core group, the individuals met actively outside of the coordinated project meetings. The informants reported that the overall activity level in the project was good and, excluding one company, all actively participated in two-day steering group meetings. C17 joined the project during its execution. They had participated in previous development activities that were part of the project's scope and had spotted the ongoing project in a newspaper. This led them to contact the coordination team of the project and to subsequently join it.

**Manifestations of relational social capital:** Knowledge was shared openly among the project members. The participant from C18 expressed that the absence of competitors and the consortium agreements "made everyone feel safe" in the project, which supported the openness. The participant also appreciated the diversity of the consortium as the participants' companies were of numerous sizes and from different places in the value chains.

**Manifestations of cognitive social capital:** Participants felt that they were able to understand each other well in project. C18 explained that fluent communication between members was at least partially due to the relatively light level of technical details in discussions. The participant from C16 felt that the discussions in the core group were genuinely interactive and that none of the members attempted to dictate the goals and actions. The project scope was loosely defined in the project plan and was mostly a description of the starting point. However, the goals and actions were defined in greater detail as the project

continued.

**KT impact:** The interaction within the core group led to a joint offer. Although C18 was part of the core group, the participant felt that they did not participate in actual R&D with other members and that the only truly beneficial knowledge, from the perspective of R&D, came from research organizations. The participant from C17 found the steering group meetings to be beneficial, particularly the informal aspects of the meetings, since these meetings provided the opportunity for obtaining feedback for their ideas. C17 also visited one consortium member to benchmark their ICT solutions in order to support R&D in C17.

**KT barriers and limiting factors:** The funding agency reduced the funding budget which, particularly from C18’s perspective, affected the ability of the consortium members to obtain concrete results that would have been more easily transferred among the firms. The collaboration with research institutes was fluent, and it covered the needs concerning the new knowledge in the project’s R&D scope.

**Collaboration platforms:** Two-day steering group meetings were held three to four times a year. While the first day was more formal, the second day was more informal and built around benchmarking the facilities of the firm hosting the meeting. Short teleconferences, which focused purely on reporting, were held every other week. C17’s collaboration was limited to beforementioned formal platforms, whereas the C16 and C18, being part of the core group, had active interaction outside of the project meetings.

**Potential synergies:** The core group made a joint offer because of project collaboration while the project was ongoing.

**Other:** C16 had the scope of the project in their technological roadmap, so it was easy to find the requisite resources for the collaboration and the project activities. The participant from C16 felt the project also helped the core group members plan shared activities for the future. The informant emphasized the importance of motivation to the project activities, such that when a firm genuinely intends to gain new knowledge and develop something new, the overall motivation in the project is much higher than that in a situation where the main reason for joining the project is to obtain external funding. The participant had wanted one passive member in the consortium to be excluded from the project; however, the participant did not suggest this in the project consortium.

5. Fuzzy-set qualitative comparative analysis

Qualitative comparative analysis (QCA) is a set-theoretic method that can be used to analyze causal conditions leading to a certain outcome or outcomes (Ragin, 2000). The analysis can focus on a single condition or a combination of conditions and recognize sufficient and/or necessary relations between condition(s) and outcome(s). In a necessary relation, a configuration of conditions or a single condition is present in all occurrences of a certain outcome, while in sufficient relation, a certain configuration leads to the same outcome (Greckhamer, 2018). To analyze necessity and sufficiency of conditions, two measures are typically used: consistency and coverage. Consistency measures the degree to which the cases with same condition(s) “agree in displaying the outcome in question” (Ragin, 2006, p. 292), and coverage measures the empirical relevance of the condition(s) in the sample.

In this section, analysis is performed for causal conditions in R&D project networks that lead to inter-firm KT and for those leading to minor, or absence of, KT between firms. Two sets of conditions were recognized during the processing of the transcribed materials and the case summaries. The first set consisted of the three dimensions of social capital: structural, relational, and cognitive. For the second set, the dimensional values of social capital dimensions were combined into a single measure and conditions of absence of limiting factors and motivation towards collaboration were included in the evaluation.

5.1. Calibration of causal conditions and outcome

Causal conditions are determined through their membership in a certain set (case). In fuzzy sets, a condition can have a partial membership, which is indicated by values between 0 and 1. In a full membership, a value 1 is given; a value of 0 is assigned if the condition has no membership in the set. Another option would be exploiting a crisp set QCA in which conditions are given binary values 0 or 1. However, in the present study this would lead to losing value from the rich qualitative data, especially related to social capital, limiting factors, and the effects of KT. The set memberships were defined based on theoretical knowledge and/or in-depth knowledge of the cases. The process in which the operationalized values of set membership are obtained is called calibration.

To support the calibration of KT fuzzy-set scores, the KT impact reported in the case descriptions (Section 4) were organized into four categories<sup>1</sup> presented on the x-axis of Table 4. Knowledge is transferred when it has impact (Argote and Ingram, 2000), so cases with the most perceived impact from KT are here considered to also have the most KT. A fuzzy-set score one (1) was given to the case with the most KT, that being Case 3, with three separate “impacts” reported. A four-step scale was used, so that, for cases in which inter-firm KT was absent, the fuzzy-set score zero (0) was given. Case 4 with one impact factor present received 0.33, and for cases with two “impacts,” 0.67 was given.

The theoretical knowledge presented in Section 2 (social capital) contributed strongly to the calibration of fuzzy-set scores of social capital conditions. The hierarchical structure (dimensions, facets, factors) used to explain social capital in Section 2, and the operationalization of feature/facet definitions into questions enabled evaluation of the presence of structural (StrSC), relational (RelSC), and cognitive social capital (CogSC) in the studied cases. A six-step scale was used to score the presence of each dimension of social capital in cases, one (1) indicating strong presence, and zero (0) indicating absence. Although I consider my review on the dimensions to be relatively detailed, that is, that the multiple facets and features were recognized, it was not exhaustive. One might also easily argue that the “ingredients” of the social capital dimensions cannot be precisely defined. For these reasons, the scores were scaled so that the cases with the highest presence of each dimension of social capital were given fuzzy-set score 1. A more detailed calibration process, using the social capital features of Fig. 1, is presented in Appendix B. Table 5 presents the fuzzy data matrix for social capital conditions together with outcome (KT).

In the second analysis, a new set of conditions was used: social

**Table 4**  
Formulation of fuzzy-set scores for KT; 1 indicates the presence of the impact, and 0 the absence of the impact.

CASE	Obtaining feedback for individual R&D plans/results	Deepening supplier/customer understanding	Collaborative business planning	Learning from others outside of project scope	Fuzzy-set score for KT
1	0	0	0	0	0
2	0	0	0	0	0
3	1	0	1	1	1
4	1	0	0	0	0.33
5	1	1	0	0	0.67
6	1	1	0	0	0.67
7	1	0	1	0	0.67

<sup>1</sup> The transcribed interviews were carefully reviewed to recognize possible KT, or learning, related to the project’s scope. However, this was not reported by participants and, thus, the category is excluded from fuzzy-set scoring of KT.

**Table 5**  
Fuzzy data matrix for social capital dimensions and KT.

CASE	StrSC	RelSC	CogSC	KT
1	0.2	0.2	0.2	0
2	0.2	0.2	0.2	0
3	1	1	1	1
4	0.4	0.4	0.4	0.33
5	0.4	0.2	0.2	0.67
6	0.2	0.6	0.6	0.67
7	0.8	0.8	0.6	0.67

**Table 6**  
Formation of the fuzzy-set score for ALF; a value of 1 indicates the presence of a reason and 0, the absence of a reason.

CASE	Changes in project length and budget	Differences in R&D interests	R&D goals were achievable alone and/or with research institute	Lack of resources/ resourcing	Fuzzy-set score for ALF
1	0	1	0	1	0.33
2	0	1	1	1	0
3	0	0	0	0	1
4	0	0	1	0	0.67
5	0	1	0	0	0.67
6	1	0	0	1	0.33
7	0	0	1	0	0.67

**Table 7**  
Fuzzy data matrix for conditions SC, ALF, and M, and the outcome KT.

CASE	SC	ALF	M	KT
1	0.20	0.33	0	0
2	0.20	0	0	0
3	1.00	1	1	1
4	0.40	0.67	1	0.33
5	0.27	0.67	0	0.67
6	0.47	0.33	1	0.67
7	0.73	0.67	1	0.67

capital (SC), absence of limiting factors (ALF), and motivation (M). The average of fuzzy-set values of social capital dimensions was used to represent social capital. To calibrate the ALF, four categories<sup>2</sup> of reasons that limit the inter-firm KT were identified from cases (the x-axis of Table 6). In Case 3, none of the reasons was present and it was given a fuzzy-set score of 1, while three reasons were present in Case 2, which was given a 0 for a fuzzy-set value. A four-step scale was used, so cases with two limiting factors a value of 0.33 was given and for cases with one limiting factor present, a fuzzy-set score was set to 0.67.

Two distinctive motivations to facilitate inter-firm collaboration were recognized from the cases: similarity of R&D goals and complementarity of the business goals. In none of the cases were both motivational factors present. In Cases 4 and 6 the similarity of R&D goals was present, and in Cases 3 and 7 complementarity of the business goals was present. For these cases, a fuzzy-set score of 1 was given for motivation. In Cases 1,2, and 5, motivation towards collaboration was not observable and the fuzzy-set score was set to 0. Table 7 presents the fuzzy data matrix for the second set of conditions and outcome (KT).

5.2. Analysis and results

The analysis was conducted with the help of the fsQCA 3.1b

<sup>2</sup> In addition, social capital related factors limiting inter-firm KT were carefully sought from interview transcriptions. However, none were identified, and, thus, the category is not used for fuzzy-set analysis.

program, which is downloadable at <http://www.socsci.uci.edu/~cragin/fsQCA/software.shtml>. The first step in the analysis was to test necessary conditions for the outcome (KT) and for negation of the outcome (~KT), as the causal symmetry is not assumed in QCA (Ryan and Smith, 2012). For a fuzzy-set QCA, a minimum consistency of 0.9 and high coverage are recommended to consider a condition necessary (Greckhamer, 2018). For a small-N study, such as that presented in this article, the consistency should (virtually) equal 1 in order for a condition to be considered necessary. Based on analysis conducted in fsQCA programme, no condition can be considered necessary.

For sufficiency analysis, a threshold of 0.8 for raw consistency is well-established (Greckhamer, 2018). In addition, a case frequency of one (1) for a configuration is typically considered adequate in small-N studies (Greckhamer, 2018). A threshold of 0.8 for raw consistency and minimum frequency of one (1) was used in sufficiency analysis. A truth-table algorithm was used to conduct sufficiency analysis for both sets of conditions for outcome (KT) and outcome negation (~KT). The results are presented in Tables 8 and 9. Configurations with no cases are excluded from tables.

For sufficiency analysis, parsimonious solutions were created from configurations presented in Tables 8 and 9 by using the Standard Analysis function of the fsQCA program. Parsimonious solutions are the least complex solutions in using the algorithm in which assumptions about remainders, that is, combinations of conditions with no case, are allowed (Ryan and Smith, 2012). Baumgartner and Thiem (2020) argued that only parsimonious solutions should be used to make causal inferences. Some authors, for example Schneider and Rohlfing (2016), are not as strict in their views. However, the literature seems to agree that parsimonious solutions are well suited for identification of causalities and, thus, they are used in the current study.

Solutions were created for outcomes of KT and ~KT and for both sets of conditions (Tables 10 and 11). The format of Tables 10 and 11 is commonly used in reporting the QCA finding (e.g. in Fernández-Esquinas et al., 2021; Pappas et al., 2016). Configuration ~ SC\*~ALF\*M was excluded from the solution analysis, as its proportional reduction in inconsistency (PRI) was significantly lower than consistency, which indicated “simultaneous subset relation of configuration in both the outcome and its absence” (Greckhamer, 2018, p. 489).

The identified solutions are discussed here briefly. The first set of conditions focused on how the three dimensions of social capital affect the KT between firms (Table 11). The QCA results are clear and highlight the importance of structural social capital. The presence of structural social capital facilitates the KT while the absence decreases the KT. The QCA results concerning the first set of conditions are discussed together with case findings in subsection 6.4 to give more detailed understanding on the causalities.

For the second set of conditions (Table 10) QCA results indicate that the presence of social capital (SC) alone or a combination of absence of limiting factors (ALF) and motivation (M) increase the likelihood of knowledge transfer between firms in R&D project networks. Interestingly, the “absence of absence of limiting factors” actually means presence of the limiting factors, which should have negative effect on KT. As a consequence, it seems that the motivation towards collaboration is capable of facilitating KT even when the limiting factors are present. On the other hand, the presence of limiting factors is recognized as a single condition to hinder the likelihood of KT (solution 3, Table 10), indicating that the recognized limiting factors do have negative effect on the inter-firm KT. The solution 4 indicates that the absence of social capital and presence of motivation is likely to have negative effect on KT. Again, the result is somewhat illogical as solution 2 highlights motivation’s importance in KT facilitation. To summarize QCA findings, the second set of conditions gives somewhat mixed results concerning the facilitative effects of motivation and absence of limiting factors. Also, the identification of combinations that either facilitate or prevent KT is difficult. However, for social capital the results are clearer, since the presence of social capital seems to facilitate KT while absence

**Table 8**  
Sufficiency analysis for configurations of social capital dimensions.

Configuration			Cases	Outcome KT		Outcome ~ KT	
StrSC	RelSC	CogSC		Consistency	Coverage	Consistency	Coverage
1	1	1	3,7	0.832143	0.697605	0.546429	0.418033
0	1	1	6	0.738889	0.398204	0.85	0.418033
0	0	0	1,2,4,5	0.45	0.458084	0.9	0.836066

**Table 9**  
Sufficiency analysis for configurations of social capital, absence of limiting factors and motivation.

Configuration			Cases	Outcome KT		Outcome ~ KT	
SC	ALF	M		Consistency	Coverage	Consistency	Coverage
0	0	0	1,2	0.183333	0.098802	1.000000	0.491803
1	1	1	3,7	0.970833	0.697605	0.441667	0.289617
0	1	1	4	0.775000	0.278443	1.000000	0.180328
0	1	0	5	0.670000	0.200599	0.660000	0.180328
0	0	1	6	1.000000	0.338323	0.823009	0.254098

**Table 10**  
Parsimonious solutions for KT and ~KT with conditions: StrSC, RelSC, CogSC.

Condition	KT	~KT
StrSC	●	○
RelSC		
CogSC		
Consistency	0.81	0.81
Coverage	0.78	0.84
Cases with greater than 0.5 membership	3,7	1,2,4,5,6

● Presence of condition  
○ Absence of condition

**Table 11**  
Parsimonious solutions for KT and ~KT with conditions: SC, ALF, and M.

Condition	KT		~KT	
	1	2	3	4
SC	●			○
ALF		○	○	
M		●		●
Consistency	0.84	1.00	0.9	0.85
Coverage	0.82	0.40	0.82	0.32
Overall solution consistency	0.85		0.91	
Overall solution coverage	0.88		0.89	
Cases with greater than 0.5 membership	3,6	6	2,1,6	4,6

● Presence of condition  
○ Absence of condition

of social capital together with motivation seems to have negative effects on KT. More detailed view on findings and causalities are given in the next section in which QCA results are discussed together with the cases.

**6. Discussion and implications**

**6.1. Knowledge transfer**

In this study, definitions by Argote and Ingram (2000) and Inkpen and Tsang (2005) are followed, so that knowledge is transferred when it has impact on the knowledge recipient. Various KT impacts or KT benefits were identified in the present study, and were categorized into the following classes: obtaining feedback for individual R&D plans/results, deepening supplier/customer understanding, collaborative business

planning, and learning from others outside of the project scope.

The classes were not weighted in the KT calibration for QCA, but had they been, the collaborative business planning would have had the highest score. Cases 3 and 7, in which this impact occurred, were the only cases in which a genuine co-creation was present.<sup>3</sup> With the exception of Cases 1 and 2, informants in all cases considered getting feedback from their individual R&D activities to have been beneficial. This was appreciated because the positive feedback created faith to continue the chosen R&D path. The results were systematically shared in the steering group meetings, but often also in other platforms, such as digital platforms and informal meetings.

Despite the identified benefits, the KT between firms was surprisingly low. An especially interesting finding was that the KT in the project's R&D scope was not present in any of the studied cases, that is, that in none of the cases were R&D results of individual firms transferred to other network member(s), nor were the R&D activities executed in collaboration. Therefore, such benefits as mitigated risks (Eisenhardt and Schoonhoven, 1996), reduced R&D costs (Littler et al., 1995) or improved innovation capability (Easterby-Smith and Prieto, 2008), typically considered being the positive results from R&D collaboration, may be hard to achieve through the inter-firm collaboration in R&D project networks. This implies that coordination of the R&D projects and innovation policy makers should, in addition to planning how to make knowledge available, emphasize creating such consortiums and means that support the actual transfer or the co-creation of the knowledge.

**6.2. Motivation to collaborate with other firms**

Two sources of motivation were identified for firms to collaborate and exchange knowledge with each other: similarity of individual R&D goals and complementary business goals. The first motivation type assumes that, as several firms work on similar R&D topics, they could, by joining resources and by means of knowledge exchange, achieve their individual goals faster, with lower costs and/or gain better results. Although the knowledge was openly shared in projects, none of the participants reported learning from other firms within the R&D scope of the project. One explanation for this is that, although the individual R&D goals of consortium members were defined under the same title(s) in the project applications, the individual goals were still too different. This led firms to rely on their own expertise and on R&D organizations/universities as sources of new knowledge.

<sup>3</sup> The co-creation of knowledge is here considered as a form of KT, as the knowledge shared between firms must be transferred frequently during the co-creation process.

The complementary business goals, with strong support from social capital, led, in Cases 3 and 7, to the formation of core groups in which the KT was intense. In Case 3, the core group shared business ideas, and in Case 7 the collaboration led to a joint offer. In these cases, the core group members had most active discussions outside of the organized project platform. It is notable that a genuine knowledge co-creation occurred only in these cases.

Motivation arose in two parsimonious solutions of QCA. Combination of motivation (M) and presence of limiting factors (~ALF) were present with KT (Table 10), and a combination of motivation and absence of social capital (~SC) occurred together with the absence of KT (Table 11). The first combination indicates that motivation facilitates KT even though factors limiting KT are present. However, this solution had low unique coverage and was present in Case 6 (greater than 0.5 membership). Although informants from C14 and C15 in Case 6 both agreed that the consortium members had similar R&D intentions, the inter-firm KT occurred only between firms that had some common commercial interests (software supplier and potential customer).

The second combination indicates that the absence of social capital leads to an absence of KT, although motivation is present. The solution occurred in Cases 4 and 6. Case 4 differed from other cases in the sense that it had modest inter-firm KT, although motivation for collaboration was present. The project coordination established excellent opportunities for knowledge exchange, but with modest social capital, together with motivation, it led to making the knowledge actively available but not for the actual transfer of the knowledge. For Case 6, the solution does not demonstrate a good explanation, as the main reason to limit the KT (between C14 and other members) was lack of resources.

### 6.3. Factors limiting KT

The individual factors limiting the inter-firm KT were categorizable under the following four classes: changes in project length and budget, differences in R&D interests, R&D goals were achievable alone and/or with research institute, and lack of resources/resourcing.

Changes in project length and budget occurred in Case 6. This potentially limited the KT as firms did not yet have concrete results from their individual R&D work, which could have been interesting from other members' perspective. It was also reported in other cases that toward the end of the project, shared knowledge became more appealing. That is understandable as firms, in general, have vast amounts of information available, but it may lack proof of concept information. Projects with multiple firm members could be effective channel for firms to gain access to R&D knowledge that is tested in real business environments, perhaps very similar to their own.

Factor differences in R&D interests, present in cases 1,2 and 5, meant that the knowledge shared by individual firms did not support the R&D intentions of other firms. Factor R&D goals were achievable alone and/or with research institute was identifiable in Cases 2, 4, and 7. It limited the inter-firm KT related to the R&D scope of the project, for example, in Case 7, in which the business-related KT was active. The collaboration between firms and research institutes is typically described in the project plans. Also, the collaboration often included funding from firms to research institutes, which creates the expectation of collaboration and knowledge flows between the firms and research institutes. However, the description of inter-firm collaboration is typically not detailed and is focused on making knowledge available—not particularly on how the knowledge created by individual firms will benefit other firms in the consortium. Perhaps the inclusion of more detailed plans of inter-firm KT in funding applications would facilitate the inter-firm KT in projects.

The first three limiting factors are strongly related to the motivation to learn from other firms, which is recognized as key factor to influence the inter-firm KT in previous literature (Easterby-Smith et al., 2008). It is noteworthy that the lack of motivation to learn originated from firms considering the content of the knowledge unappealing, not from individual traits or firms' cultures, as learning from universities and research

institutes was active in most of the cases. Two reasons can be considered to explain the unappealing nature of the knowledge. First, firms chose not to exploit the knowledge because it was not beneficial for them. Second potential reason is that the firms' knowledge bases were too different, so that the firms' did not recognize the potential benefits the shared knowledge offered (see knowledge distance in Cummings and Tseng, 2003).

Lack of resources/resourcing limited the inter-firm interaction in cases for two reasons. From a quantitative perspective, the challenge was that the firms' representatives did not have the time available to identify knowledge synergies with other firms. It was also communicated that, with research institutes, the problem was not present, as research institutes actively coordinated the collaboration. From a qualitative perspective, it was found that the inter-firm collaboration would have required a wider involvement of personnel in project activities. This would have enabled discussions on multiple potential collaboration topics directly between experts. Lack of resources/resourcing can be associated with the lack of absorptive capacity, as firm's willingness and ability to invest in knowledge-building activities is in the core of the formation of absorptive capacity (Song et al., 2018). On the other hand, in Case 4, the personnel were widely involved in project activities that did not lead to substantial inter-firm KT, indicating that resourcing does not guarantee the transfer of the knowledge.

QCA offers one solution in which the presence of limiting factors together with motivation leads to KT. This was discussed in a previous sub-section; however, the presence of limiting factors (absence of ALF) is associated with the absence of inter-firm KT (Table 11). The solution was present in Cases 1, 2, and 6. The results suggest that, the absence of the limiting factors does not seem to be sufficient to facilitate the inter-firm KT. However, the presence of limiting factors can hinder or even prevent the facilitative impact of social capital and/or motivation.

### 6.4. Social capital

The QCA results emphasize the importance of social capital for inter-firm KT. Social capital, as a single condition, was a parsimonious solution for KT (Table 10) and present in Cases 3 and 7. In addition, a combination of absent social capital with motivation led to hindered KT, and present in Cases 4 and 6. However, in Case 4, the scant presence of social capital may limit KT, but overall, the observed conditions don't seem to explain the outcome (~KT) very well, even when the case description is studied. In Case 6, as explained in Section 6.1, the KT was primarily limited by the lack of resources, and less by insufficient social capital.

In Cases 3 and 7, the social capital clearly facilitated the KT. Cases 3 and 7 were the only cases in which the firms collaborated to create new business opportunities that required outputs from all core group members. It seems that the motivation and social capital fed each other. The potential of the collaborative business opportunity created a motivation to interact openly, and perhaps on multiple topics, so that the social capital could start to accumulate as part of the interaction. On the other hand, the social capital not only increases the ability to collaborate, but also the motivation to collaborate (Tsai and Ghoshal, 1998).

What makes Case 3 unique among the studied cases is that, despite the fact that the participating individuals had no previous experience working together, the social capital had the highest presence in that case. Actually, the firm representatives met for the first time in a meeting in which they presented their project plan to the funding agency. At least in Cases 1 and 4, many of the people had experience working together, but this did not lead to a substantial presence or development of social capital. This indicates that social capital can develop rapidly among members if the circumstances are favorable, though the history of collaboration does not guarantee the development of social capital.

In Case 3, at least two reasons for the formation of "favorable circumstances" can be identified. First, the right kind of people, who enjoyed each other's company and had mutual interests, were brought

together by the coordinator, who was responsible for creating and nurturing the consortium. Second, they had a market survey executed in an early phase of the project. The results were conducted by a research institute but were interpreted by the firms together. This kind of participatory activity is likely to promote the embeddedness of social relationships and point the collaboration in the right direction for social capital to develop. Also noteworthy in Case 3 is that it was the only case in which “learning outside of the project scope” occurred. The learning concerned factors related to organizational culture and behavioral matters, or “ability to be a better partner,” as expressed by the participant. This kind of knowledge has a strong tacit and private element to it, while the knowledge transferred in the other studied cases was more explicit in nature. As the social capital was most developed in Case 3, the beforementioned highlights the importance of social capital in the transfer of tacit knowledge. The finding is in line with previous literature, for example, Dhanaraj et al. (2004), or Uzzi and Lancaster (2003), who considered social embeddedness to facilitate the transfer of private knowledge.

The effects of social capital dimensions on KT were also evaluated separately. The QCA results (Tables 10 and 11) clearly highlight the importance of the structural dimension of social capital. This QCA result corresponds to the view sometimes presented in the literature that the structural social capital predicts other dimensions (Li et al., 2013). This is logical in the sense that connections between individuals are the backbone of structural social capital and create positive circumstances for other dimensions to develop. A closer inspection of the cases gives some support to this, as the variation between the social capital dimensions seems to be low within individual cases; that is, if one dimension is weakly developed, others are also, and if one dimension is strong, others are also. This indicates that the dimensions support each other's development. However, causalities between dimensions are hard to determine from the research data and do not necessarily demonstrate that the presence of structural social capital anticipates the development of the other two dimensions.

Trust is often considered a significant factor that effects inter-firm collaboration and has been the focus of several KT studies (e.g., an intra-firm study by Levin and Cross, 2004; between universities and industry, Santoro and Saporito, 2006; buyer–supplier relationships, Squire et al., 2009). Indeed, the trust and trustful atmosphere was often mentioned during the interviews. In this context, trust refers to the goodwill trust. However, the trust was associated with the willingness to share the knowledge within the project network, which, quite surprisingly, did not seem to facilitate KT. On the other hand, the knowledge was shared openly during the project meetings in all cases, also in the ones in which presence trust was not emphasized by informants. In addition, no participant reported any trust-related problems. In light of these findings, it seems that trust is not among the critical factors that facilitate the KT in R&D project networks. From the project coordinator's perspective, non-disclosure agreements, which were routinely used in the studied projects, was likely enough to build the required trust among the consortium members.

Social capital can allow firms to get access to new sources of knowledge (Inkpen and Tsang, 2005) and facilitates knowledge transfer (e.g. Gooderham et al., 2011; Eisenhardt and Santos, 2002). The former benefit was not identifiable in the studied context. The studied R&D project networks had stable memberships in which all firms openly made their knowledge available for other network members. Thus, it is logical that the presence of social capital did not increase the number of firm contacts that could have been the new sources of knowledge. It would also be possible that social capital increased connections between individuals from different firms and thus increased the sources for knowledge. However, this did not occur in the studied cases, as the interaction focused between the firms' project representatives. Considering the latter benefit resulting from social capital, the findings of the present study are consistent. The social capital increased the interaction between individuals and thus facilitated the transfer of the knowledge as

more KT opportunities occurred. In addition, social capital allowed access to such knowledge contents that were not shared in the formal collaboration platforms and projects with low presence of social capital.

## 7. Conclusions and limitations

In this paper, a study on inter-firm KT and conditions facilitating the KT in the context of R&D project networks has been presented. During the preliminary analysis of the case data, relevant conditions that seemed to facilitate KT were identified as social capital and motivation. Also, several mixed factors that limited KT, were recognized. Furthermore, the impacts that the KT had on firms were identified. The QCA and in-depth case analysis presented in the current article support the findings of preliminary analysis, that, indeed, the identified conditions are relevant for inter-firm KT to occur.

The results suggest that the presence of social capital does facilitate the inter-firm KT in the studied context, but it needs to be accompanied by shared business intentions in order to obtain the most beneficial outcomes. In addition, the so-called limiting factors can mitigate the facilitative influence of motivation and social capital.

The effects that the structural, relational, and cognitive social capital had on KT were studied separately. Although QCA analysis emphasized the importance of structural social capital, it seems that all three dimensions support the development of each other and facilitate KT as one entity. It is also noteworthy that under favorable circumstances the development of social capital can be rapid. This means that the social capital can develop into strong facilitative force, not only in long lasting relationships, but also in contemporary networks, such as those analyzed in this article.

Interestingly, the R&D knowledge made openly available in all cases, did not seem to benefit the firms. Overall, it seemed that much of the potential related to inter-firm KT was left unexploited. The recommendation for innovation policy makers and project coordinators would be that, along with the facilitation of making the knowledge openly available, the network conditions presented in the study should be systematically developed to support the actual transfer of the knowledge.

Despite the aforementioned contributions, the study had its limitations. These limitations can guide future research on KT dynamics in R&D project networks or in other network types with a contemporary nature. The data for the study was collected from cases in one country in which “small circles” and similar socio-economic backgrounds of participants characterized the collaboration. Research conducted in other regions and/or with a quantitative approach could confirm and refine the presented findings. Fewer cases with a narrower theoretical lens, for example, absorptive capacity or a single dimension of social capital, could create the possibility of an even deeper understanding of KT-related causalities. In addition, a longitudinal single case study could identify causalities between the dimensions of social capital, which were left mostly unidentified in the present study.

## Declaration of competing interest

None.

## Acknowledgements

This research was supported by Tekes – Finnish Funding Agency for Technology and Innovation. The author would like to thank professors Minna Lanz and Pauli Kuosmanen for their helpful comments and suggestions. The author is grateful to colleagues Nillo Halonen and Dr. Jari Laine for the research collaboration that built the foundations for this article. Also, the author thanks Dr. Stephen Fox for his kind and encouraging support during the writing process and Dr. Jaani Väisänen for the help with the QCA implementation.

## Appendix A. Interview Protocol

### Background information

- Participant: work title and responsibilities, role in the project (was participant the primary firm representative in the project?), stage of joining the project, estimation of percentage of work time used for project activities
- Project/network's goal, firm's goal in project, members in project network, customers and suppliers in the consortium, previous collaboration with other members, previous collaboration with the coordinator, budgets (program, project, firm, coordination), duties of coordinator
- Firm: field of business, number of staff members, share of white-collar workers, turnover, firm's growth during the project, business prospects during the project, presence of R&D roadmap and the extent to which it is followed

### Planning phase of the project

- Who (organizations/individuals) coordinated the project planning?
  - o Building the consortium and creating the project plan
- Who (organizations/individuals) was involved in the project planning?
- How was consortium built? For example, recognition of potential members
- How did the firm get involved in the project?
- What was effective in the planning?
- What should have been done otherwise?
- Why did you (firm and participant) joint the project?
- What was the level of detail and concreteness of project plan?
  - o Was the project plan followed?
  - o Was the plan updated during the project?

At this point the project phases/milestones were identified and recorded into tables. The amount of interaction with other firms was defined for each stage using the scale from 0 (=no interaction) to 3 (=intense interaction). The table was visible for the rest of the interview session. The fundamental aim was to find explanations for the interaction or lack of it in each phase. The questions listed below were used to accomplish this aim. Many additional questions were asked following the informants' answers. On the other hand, the questions demonstrated some intentional overlap. This helped to delve deeper into the topics, e.g., in situations when participants were vague in their answers.

### Question used to gain understanding on interaction impact

- What knowledge was exchanged?
- What was the impact of exchanged/received knowledge?
- How was the available knowledge exploited?

### Questions used to explain the absence of interaction

- What limited the exploitability of the available knowledge? Why wasn't the available knowledge exploited more?
- Why do you consider the collaboration with others bad?
- What did you dislike in the interaction with other members?
- What limited the interaction? Why wasn't there more interaction with other firms?
  - o Internal and external factors

### Questions used to explain the presence of interaction

- Why did you interact with other members?
- Why do you consider the collaboration with others good?
- What coordinative actions were taken in the project to facilitate inter-firm interaction?
- What did you appreciate in the interaction with other members?
- What factors facilitated the collaboration/knowledge transfer/interaction?

### Neutral questions on interaction circumstances

- With whom did the interaction occur (firms and individuals)?
  - o Frequency
- In what kinds of circumstances did the interaction occur? Atmosphere?
- What were the formal and informal interaction platforms?
- What would you do similarly in future projects? And what differently?
- What were the similarities and differences between you and your firm, and other individuals and firms?
  - o Did this effect the collaboration?
- How was the interaction resourced? Was it sufficient?
- Was the communication with others fluent?

**APPENDIX B. Presence of social capital features in cases and fuzzy-set scoring**

CASE	STRUCTURAL SC		RELATIONAL SC		COGNITIVE SC	
	Score	Explanation	Score	Explanation	Score	Explanation
1	0.2	Ties: between firms. Density, connectedness: inter-firm connections limited to steering group meetings to which all companies participated. Stable. Hierarchical.	0.2	Goodwill trust. Knowledge shared openly in formal steering group meetings.	0.2	Goals explicitly defined in the project plan.
2	0.2	Ties: between firms. Density, connectedness: inter-firm connections limited to steering group meetings to which all companies participated. Stable.	0.2	Knowledge shared openly in formal steering group meetings.	0.2	Goals explicitly defined in the project plan
3	1	Ties between firms, and strong ties between individuals and firms in the core group. In the core group density and connectedness high (plenty of informal meetings), in the whole network connections limited to the steering group meetings to which all companies participated. Stable.	1	Knowledge shared openly in formal and informal (core) meetings. Openness towards new knowledge (core). Teamwork (core). Strong presence of obligations and expectations (core). Goodwill trust (core). Identification (core). Willingness to value and respond to diversity.	1	Cultural awareness. Shared norms and values. Goals explicitly defined in the project plan. Goals set also outside of the project plan (core).
4	0.4	Ties between firms. Density, connectedness: firms connected through digital platforms and coordinated meetings to which all companies participated. Stable.	0.4	Goodwill trust. Knowledge shared openly in formal steering group meetings, in other coordinated meetings and on digital platforms.	0.4	Goals loosely defined in the project plan, but concrete goals set annually. Shared norms.
5	0.4	Ties mainly between firms, but also weak ties between individuals. Density and connectedness: inter-firm connections limited to steering group meetings to which all companies participated. Stable.	0.4	Goodwill trust. Knowledge shared openly in formal steering group meetings.	0.2	Goals explicitly defined in the project plan
6	0.2	Ties: between firms. Density and connectedness: inter-firm connections limited to steering group meetings to which all companies participated. Stable.	0.6	Knowledge shared openly in formal steering group meetings. Willingness to value and respond to diversity.	0.6	Goals explicitly defined in the project plan. Shared norms. Shared language.
7	0.8	Ties between firms, and strong ties between individuals and firms in the core group. In the core group density and connectedness high (plenty of informal meetings), in the whole network connections limited to the steering group meetings to which almost all companies participated. Minor instability.	0.8	Goodwill trust. Knowledge shared openly in formal and informal (core) meetings. Willingness to value and respond to diversity.	0.8	Shared language. Shared values and norms (core).

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