

**How Firms use University-Industry Collaboration to Innovate: The Role and
Development of Social Capital and Proximity Dimensions**

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PhD dissertation submitted to
Bodø Graduate School of Business
for the degree of Ph.D
University of Nordland

Acknowledgement

Finally, I have reached the last step in the development of this thesis, where I can pay tribute to all the fantastic people who have motivated and supported me through this exciting, enjoyable, and sometimes frustrating journey. I could not have completed this process as a lonesome traveler. First, I will give my special thanks to Professor Roger Sørheim at NTNU and Bodø Graduate School of Business for being an engaged, inspiring and supportive supervisor. I had the chance to participate in your lectures in my the bachelor's degree studies, which fascinated and inspired me to continue with my master's studies and to pursue a PhD. Thanks for understanding me and believing in me; this PhD thesis would never been completed without your engagement and support. You have given me the space to learn and have offered your time in listening to and discussing my numerous questions during this process. Thanks for all your motivating words, helpful and constructive comments and conversations, which have both improved my research and made this process enjoyable. I really appreciate it. Roger, it has been both a pleasure and a comfort to have you by my side in the PhD process. Finally, I thank you for your engagement in developing the research environment at HHB, Campus Helgeland, by employing PhDs and developing the Center for Industrial Development.

I would like to give special thanks to my supervisor, associate professor Einar Rasmussen at Bodø Graduate School of Business, for all your support during this process. I feel privileged for the opportunity to learn from such a skilled researcher. I am very happy that I was invited to participate with you on a research project at the beginning of my PhD work, where we collected data and then wrote two articles together: It was both educational and inspiring to see “research in action” performed by an expert. Thank you for all our conversations, for taking the time to discuss my numerous questions, and for all your thorough comments and constructive questions related to my PhD work, which pushed me to improve my research and analytical

research competence. Einar, I am very grateful for all I have learned from you. Finally, I thank you for being a pleasant traveling companion at seminars and conferences.

I would also like to give special thanks to Siri Jakobsen, PhD student at Bodø Graduate School of Business, Campus Helgeland, for always supporting, engaging and motivating me in the process of writing this thesis—and for being such a good friend. Thanks for calming me in stressful periods, for pushing me to think twice before I rushed into action, and for engaging in me in valuable conversations that improved my research. It was a pleasure to collect data and write an article together with you, and I am thankful for all I have learned in working with you. I am grateful for having you as my companion during this process, for our friendship, and for all the fun we have had, which has made this PhD journey enjoyable.

Furthermore, I would like to express my heartfelt thanks to Krister Salamonsen, Thomas Luvås and Marit Breivik, my fellow PhD students at Bodø Graduate School of Business, Campus Helgeland, for providing good advice, support and humor along the way. Sharing this experience with you has been motivating, educational and—at least as important—fun. Special thanks are meant for Thomas. It has been a pleasure to collect data with you. Thank you for all your interesting discussions and reflective questions, which improved my research. I also wish to express my thanks to all my fellow PhD students at Bodø Graduate school of Business. It has been a pleasure to share experiences in seminars and PhD courses with you.

I would also like to thank Professor Gry Agnete Alsos at the Bodø Graduate School of Business for providing constructive comments on my work and for generously sharing insights and suggestions. Thanks are also due to Professor Paul Westhead, Durham University and Bodø Graduate School of Business, for offering constructive and helpful comments on my papers.

I am grateful for the good working relationships I have with all my colleagues at University of Nordland, Campus Helgeland. Thanks are due to Anneke Sijtske Leenheer, head of the section at Bodø Graduate School of Business, Campus

Helgeland, for providing motivation and support during this process, for offering so many encouraging words, and for facilitating the good working conditions at the Campus Helgeland; I am very grateful for the work that you do. I am also grateful to the administration and faculty of Bodø Graduate School of Business and the administration of the section at Campus Helgeland for their help and service. I would also like to extend a warm thank you to Irene Bursvik, advisor at UIN, Campus Helgeland, for all the service and care you provided during this process.

I would like to express my gratitude to all the people I have interviewed in connection with my PhD research. Thank you for taking the time to talk with me and for sharing your insights and experience with me, which provided me with the real content of this thesis. Special thanks go to Arve Ulriksen, CEO at Mo Industrial Park, who has taught me so much and has motivated me by generously sharing insights during this process.

I also want to thank Helgeland Sparebank for co-funding my research and for contributing to the development of the Center for Industrial Development at Bodø Graduate School of Business, Campus Helgeland. Thanks are also due to Bjørn Audun Risøy, Tone Jakobsen, Torbjørn Aag and Monica Paulsen, project managers at Kunnskapsparken Helgeland, for your support and engagement in my PhD work; I am grateful for our helpful collaboration.

I want to thank all my dear friends who have supported me during this process and who have provided me with enjoyable moments apart from discussing research questions: You give me energy.

Finally, I want to thank my dear parents, Lisbeth and Terje, for your support and for all our valuable conversations. Thanks for making me believe in myself, for not pushing me to do something I did not want to do, and for teaching me to act on my gut feelings and to enjoy life. As my clever mom says, "it is not the goal but the process leading up to the goal that matters". I also want to thank my dear big brother Martin and my cousins Tine and Rolf for being supportive and for showing interest in my

work, as well as Wenche and Kenneth for providing support and for helping out with your granddaughter. Further, I want to express my love and gratitude to my dear Ørjan for being a supportive partner and such a good father. My final thanks go to my dear daughter Freidis: you make my life meaningful by just being you.

Marianne Terese Steinmo

Mo i Rana, December 2014

Abstract

This thesis aims to elucidate the development of social integration mechanisms in university-industry collaborations that foster firm innovations. Universities and public research organizations (PROs) are important knowledge sources for firms to gain access to new ideas in the development of innovations because such organizations add relevant expertise and new knowledge to firms' technological resource bases.

Although many firms recognize the importance of collaborating with PROs in innovation development, they are often reluctant to use these external knowledge sources because they find it challenging to achieve effective collaboration. Differences in organizational structures, management and problem solving among collaborative partners sometimes render collaboration between academic and commercial entities challenging. The challenge often relates to the development of trust and the establishment of a common understanding in communication and interaction between firms and PROs. An emerging body of literature indicates that social integration mechanisms (i.e., social capital and proximity dimensions) play an important role in explaining the effectiveness of university-industry collaboration by facilitating interaction between firms and PROs. Accordingly, this thesis aims to answer the following research question: *“How are social integration mechanisms developed in university-industry collaboration to foster firm innovations?”* To do so, this thesis explores social integration mechanisms that are likely to influence the *process* leading to innovations. The theoretical concepts of social capital and proximity dimensions are used to examine the collaborative process because these concepts focus on interactions between collaborative partners and are thus suitable for an in-depth investigation of the organizational dynamics underlying university-industry collaboration, as called for by Perkmann and Walsh (2007).

Based on qualitative case studies of firms and projects in three types of research programs within the Research Council of Norway, this thesis addresses three

research questions in four empirical articles. The first research question addresses how a coopetition alliance facilitates can increase absorptive capacity through proximity dimensions. Social, cognitive and technological proximities are crucial for firms in a coopetition alliance to increase their absorptive capacity. Further, coopetition alliances help build trust and openness among the participating firms by means of longstanding close relationships and collaboration.

The second research question addresses how different social integration mechanisms contribute to successful innovation projects in firm-PRO collaborations. The results regarding research question 2 show that the extent to which different proximity dimensions are important for the establishment of new collaborations depends on a firm's characteristics. Whereas engineering-based firms tend to rely on geographical and social proximity to PROs, science-based firms rely more heavily on cognitive and organizational proximity. Moreover, the findings for research question 2 contribute to the open innovation and absorptive capacity literature by disentangling those social integration mechanisms through which firms are able to build and realize their absorptive capacity. Firms use different paths to build the social capital required for successful collaboration depending on their prior experience.

Finally, research question three addresses how firms can develop cognitive and relational social capital in relationships with PROs to mitigate tensions and to build fruitful collaborations in research alliances over time. The findings for research question 3 contribute to theory on how development of cognitive and relational social capital can mitigate collaborative challenges, encourage fruitful collaboration between firms and PROs in research alliances over time, and lead to the development of innovations. The findings demonstrate that the presence of cognitive and relational social capital at three levels—specifically, the individual, organizational, and alliance levels—constitutes a crucial and determining feature of fruitful collaborations between firms and PROs in research alliances with respect to releasing a firm's innovation potential.

Overall, the results of this thesis show how social capital and proximity dimensions are developed in university-industry collaborations to foster firm innovations. Building social integration mechanisms takes time and effort, but making these investments is important for innovation development because they promote the underlying mechanisms that drive successful collaboration, such as personal relations, trust, and common goals and understanding. As its primary contribution, this thesis makes findings with implications for firms that are struggling to achieve effective collaboration with PROs in areas in which innovation development is limited; moreover, this thesis proposes theoretical frameworks for *how* firms can use PROs as collaboration partners in university-industry collaboration and achieve innovation development.

First, to capitalize on their existing relationships and to create new and efficient relationships, firms must understand how to manage and organize their social relationships. Dedicated involvement and contribution from a firm is essential to establishing proximity and developing social capital, which are key mechanisms that undergird those successful university-industry collaborations in which a firm builds trust, common goals and understanding. Although active engagement is a costly strategy, firms will likely receive greater benefits from investing resources in line with their interests over time. Second, the most important implication of the present findings for PROs seeking to establish R&D collaborations with firms is the need to develop personal relations with collaborative firm partners based on trust and common understanding. Third, a central finding of this thesis is that it takes time to build social capital and establish proximity in university-industry collaboration. This finding indicates that a long period of time is necessary for firms to develop innovations through university-industry collaborations. Firms and PROs require time to reach common understandings and develop personal relations that can lead to establishing common working conditions in which all the partners' needs are met. An

extended time horizon for policy, firms, and PROs is important, and policy makers should show patience with respect to fostering innovation development.

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1. Introduction

This thesis aims to understand how social integration mechanisms are developed in university-industry collaborations to foster firm innovations. Innovation is a central driving force behind firm performance and profitability (Teece, 2007). Nonetheless, many firms find it difficult to develop innovations (Katila and Ahuja, 2002). The open model of innovation and related traditions within innovation studies highlight the importance of external sources of knowledge as a complement to internal knowledge (Chesbrough, 2003, Chesbrough et al., 2006, Von Hippel, 1988). Universities and public research organizations (PROs)¹, are important knowledge sources for firms to exploit to gain access to new ideas in the development of innovations because such organizations can add relevant expertise and new knowledge to a firm's technological resource base (Dahlander and Gann, 2010).

Although many firms recognize the importance of collaborating with PROs in innovation development, it is far from easy for firms to identify and assimilate relevant external knowledge sources (Cohen and Levinthal, 1990), and firms are often reluctant to use external knowledge sources because they find it challenging to achieve effective collaboration with external partners. The challenges in university-industry collaboration are often rooted in tensions between firms and PROs, which can be defined as "two co-existing contradictory forces with conflicting goals" (Fang et al., 2011, p. 774). Differences in organizational structures, management, goals, and problem solving between collaborative partners sometimes render collaborations between academic and commercial entities and activities challenging (Ambos et al., 2008). Whereas the aim of PROs is to educate and perform fundamental academic research, firms seek to develop commercially valuable products and services (Ambos et al., 2008). Further, PROs often have a long-term orientation, whereas firms are

¹ The term 'PROs' is used to include universities and 'public research organizations', which are predominantly government-funded.

more oriented toward short-term, applied research that can lead to solutions to current problems (Spithoven et al., 2011). This scenario can lead to tensions between academic and commercial activities (Ambos et al., 2008) and can result in a variety of organizational barriers (Bruneel et al., 2010).

Having sufficient absorptive capacity has been shown to be a necessary precondition of knowledge transfer and innovation in firms (Spithoven et al., 2011), where absorptive capacity is defined as “the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends” (Cohen and Levinthal, 1990, p. 128). The previous literature has highlighted the determinants for the development of absorptive capacity in firms. First, firms absorb external knowledge more effectively when they also perform some amount of R&D internally (Cohen and Levinthal, 1990). Second, external R&D increases a firm’s internal R&D as long as the firm already possesses its own absorptive capacity (Veugelers, 1997). Third, firms with close relationships with several external partners perform significantly better with respect to innovation than firms with only one close external relationship (Murovec and Prodan, 2009). Finally, firms with higher absorptive capacity, which generally have greater expertise and greater capacity to recognize emerging technological opportunities, are more proactive in exploring new opportunities. By contrast, those firms with lower absorptive capacity tend to be more reactive and tend to search for new alternatives in response to failure (Cohen and Levinthal, 1990)

Although the positive effects of absorptive capacity on successful university-industry collaboration are well documented, the organizational antecedents of absorptive capacity have been studied far less extensively (Van Wijk et al., 2008), and the organizational mechanisms behind the creation and persistence of absorptive capacity is not well documented (Schleimer and Pedersen, 2013, Ebers and Maurer, 2014). It is widely accepted that social processes are highly influential with respect to organizational behavior and effectiveness (Granovetter, 1985). Zahra and George

(2002) have suggested that firms with similar levels of potential absorptive capacity may differ in their level of realized absorptive capacity depending on how they use social integration mechanisms. Social integration mechanisms facilitate the sharing and exploitation of knowledge and the transformation of new knowledge through social networks (Zahra and George, 2002). This thesis builds on theory regarding the role of social integration mechanisms in enhancing university-industry collaboration to develop firm innovations. The overall research question for this thesis is as follow: *“How are social integration mechanisms developed in university-industry collaboration to foster firm innovations?”*

Table 1-1 Research questions of this thesis

RQ	Paper(s)	Context	Theoretical approaches
1: <i>How does a coopetition alliance facilitate increased absorptive capacity through proximity dimensions?</i>	1	Coopetition alliance	Coopetition, absorptive capacity and proximity dimensions: Social, cognitive, geographical, technological, institutional, cultural
2: <i>How do different social integration mechanisms contribute to successful innovation projects in collaborations between firms and PROs?</i>	2	Innovation projects	Proximity dimensions: Geographical, cognitive, organizational, social
	3	Innovation projects	Absorptive capacity and social capital: Structural, cognitive and relational
3: <i>How can firms develop cognitive and relational social capital in their relationships with PROs to mitigate tensions and to build fruitful collaboration in research alliances over time?</i>	4	Compares firms within two research alliances	Social capital: Cognitive and relational

Whereas the effects of links between firms and PROs on innovation are extensively studied, the organizational dynamics underlying these relationships remain under-researched (Perkmann and Walsh, 2007). Moreover, scholars have called for more in-depth research on those factors that make university-industry

collaboration successful (Giuliani and Arza, 2009) and for research aiming at illuminating the innovation process, social interactions and knowledge creation in university-industry collaborations (Smith, 2012). Relying on social integration mechanisms (i.e., social capital and proximity dimensions), this thesis responds to these gaps, as they both focus on similarities, closeness, and social interaction among collaborative partners in university-industry collaboration for the development of innovations.

First, social capital can be defined as “the aggregate of resources embedded within, available through, and derived from the network of relationships possessed by an individual or organization” (Inkpen and Tsang, 2005, p. 151). It has been suggested that social capital is important to the development of absorptive capacity in university-industry collaboration because it helps firms identify and forge effective relationships with relevant partners (Tether and Tajar, 2008). Second, an emerging body of literature indicates that different dimensions of proximity facilitate interactions between firms and academia (Boschma, 2005, D'Este et al., 2012). The proximity concept refers to “being close to something measured on a certain dimension” (Knoben and Oerlemans, 2006, p. 72) and in the firm context, proximity concerns the similarities between firms and their collaborative actors, which may provide different advantages, such as increased absorptive capacity (Boschma, 2005, Knoben and Oerlemans, 2006).

To address the overall research question, this study explores three different contexts of research and development (R&D) collaborations. The first R&D collaboration in this study involves 15 user-driven innovation projects (BIPs) with high innovation potential, in which a lead firm runs the project and collaborates with at least one PRO and frequently with other firms as partners.

The second research alliance in this thesis involves a coopetition alliance, Norwegian Ferroalloy Producers Research Association (FFF) that conducts common R&D projects to develop environmental innovations. This alliance consists of

competing firms within the Norwegian Ferro-alloy industry and their external PRO partners, which participate in and run each project.

The last research alliance in this thesis involves the Centers for Environment-friendly Energy Research (FME), which conducts long-term international research to solve specific challenges in the energy industry through innovative solutions. A university college, university or a research organization runs each FME alliance. In addition, firms collaborate over large parts of each branch's value chain, and other PRO partners participate.

These three types of university-industry collaborations are chosen to explore the development of social integration mechanisms in university-industry collaboration to foster firm innovations because they all involve R&D collaboration to develop innovation, and each includes firms and PRO partners. These research programs also differ in terms of management, time horizons and innovation outcomes, which permits us to investigate similarities and differences across types of collaborations.

The core of this thesis consists of four academic papers. To enhance the understanding of organizational dynamics underlying university-industry collaboration (Perkmann and Walsh, 2007), a qualitative case-study approach is employed because it can yield insight into complex relationships and processes through in-depth information (Yin, 2009). The overall research question is addressed through three discrete research questions. These research questions are answered by the four papers included in this thesis, which use different contexts of R&D collaborations and theoretical approaches to explore how social integration mechanisms are developed in university-industry collaboration to foster firm innovation, as illustrated in Table 1-1.

First, this thesis will identify social integration mechanisms that enable competitive firms to accumulate knowledge when working on R&D projects with PRO partners. The first research question of this thesis is thus as follows: *“How does a*

coopetition alliance facilitate increased absorptive capacity through proximity dimensions?” This question is addressed in the first paper, which explores how a coopetition alliance can increase the absorptive capacity of alliance members through proximity dimensions and thereby facilitate innovation through common R&D projects. To answer this research question, a longitudinal study is undertaken of five firms and their collaborative research partners within one coopetition alliance in the Norwegian Ferro-alloy industry.

Next, innovation projects play a critical role in the development of innovations, and studying specific innovation projects may provide more precise information on specific collaborations. A second aim of this thesis is to explore how social integration mechanisms are developed in collaborative innovation projects managed by firms. Accordingly, the second research question is as follows: *“How do different social integration mechanisms contribute to successful innovation projects in collaborations between firms and PROs?”* This question is addressed in papers 2 and 3 through a longitudinal study of 15 successful innovation projects that involve firms and PROs as collaboration partners. Two different theoretical perspectives are employed to address this research question. Paper 2 explores how different dimensions of proximity facilitate successful collaborations between firms and PROs and how these dimensions evolve over time. Paper 3 explores how different dimensions of social capital contribute to successful innovation projects in collaborations between firms and PROs and how different dimensions of social capital interact over time.

Finally, this thesis aims to further the understanding of how firms manage to collaborate in long-term research alliances by exploring the third research question: *“How can firms develop cognitive and relational social capital in their relationships with PROs to mitigate tensions and build fruitful collaborations in research alliances over time?”* This question is addressed in paper 4, which explores how the development of social capital mitigates challenges between firms and PROs in research alliances and facilitates successful collaboration over time. This paper

compares firms within the FME research alliance to firms within the FFF cooperation alliance. Firms in both research alliances are aiming to develop environmental innovations but are in different developmental phases and have experienced different innovation outcomes.

1.2 Intended contribution

This thesis aims to augment the understanding of how social integration mechanisms are developed in university-industry collaboration to foster firm innovations. By exploring three types of collaborative research programs with the theoretical concepts of social capital and proximity dimensions, this thesis aims to provide findings with implications for firms struggling to achieve effective collaborations with PROs. These implications will contribute to our knowledge of how different types of firms can form strategies for developing social capital and proximity dimensions to benefit from university-industry collaboration. For instance, firms with less R&D experience might have a different strategy for developing social integration mechanisms than firms with more R&D experience. This thesis also intends to make findings that have implications for how research programs might be designed to facilitate successful university-industry collaborations and innovation development and to encourage more productive resource investment.

Further, the present research aims to construct theoretical frameworks regarding *how* firms use PROs as collaborative partners in university-industry collaboration for the development of innovations, which requires a deeper understanding of the micro-level mechanisms involved in university-industry collaboration, such as individuals, processes, structures, and their interactions (Felin et al., 2012). Using specific social integration mechanisms, i.e., social capital and proximity dimensions, this thesis seeks to strengthen the robustness of the university-industry collaboration literature, which will likely facilitate further theoretical development regarding such collaborations. Most prior research on the role of

collaborative processes in university-industry collaborations has been cross-sectional and quantitative in nature and has examined the factors that lead to establishing collaborations. By contrast, this thesis focuses on the development process in ongoing university-industry collaborations in which social integration mechanisms are developed to foster innovations and thus aims to reveal how collaborations emerge and evolve over time.

Furthermore, this thesis contributes to the literature by extending the literature on social capital and proximity dimensions; more specifically, it contributes to a more dynamic understanding of how different dimensions of proximity and social capital are related and how they interact and develop over time. Finally, this thesis contributes to the literature by integrating social capital and proximity dimensions into university-industry collaborations. This thesis thus discusses the similarities and differences as well as the strengths and weaknesses among the perspectives and considers when and where these perspectives are most useful for studying university-industry collaboration.

1.3 Outline of the thesis

This thesis proceeds as follows. Chapter 2 develops a theoretical framework to explore university-industry collaboration. This chapter begins by conceptualizing the term university-industry collaboration and highlighting earlier research and literature gaps related to this concept. Then, the integration mechanisms—specifically, social capital and proximity dimensions—which this theoretical framework builds upon, are presented. At the end of chapter 2, a conceptual framework for this study is presented. Chapter 3 presents the methodology, including the context, research design, data collection, analysis, and ethical considerations. Chapter 4 presents a summary of the four papers. Chapter 5 begins by presenting the key findings and their implications for firms, PROs and policy makers. At the end of chapter 5, the limitations

of the study and suggestions for further research are presented. In the second part of this thesis, each of the four articles is presented.

2. Theoretical insight

2.1 Introduction

To explore how social integration mechanisms are developed in university-industry collaboration to foster firm innovations, this chapter begins by conceptualizing the university-industry collaboration perspective and identifying research gaps. Further, the social integration mechanisms examined herein—social capital and proximity dimensions—are presented. Finally, a conceptual framework is presented.

2.2. University-Industry collaboration

Developing innovations can be a complex task that requires knowledge beyond firms' core competence, and because of the competitive pressures that many firms face, firms often seek to complement their in-house knowledge with external R&D (Lane and Lubatkin, 1998, Hagedoorn, 2002, Sampson, 2007). Higher productivity and economic benefits are achieved by giving firms the possibility to conduct high quality research with research partners as a key source for innovation (Laursen and Salter, 2004, Nieto and Santamaria, 2007). Because firms' external knowledge sources are important for innovation development (Lane and Lubatkin, 1998), research on university-industry collaborations has increased considerably (e.g. Bodas Freitas et al., 2013, Gulbrandsen et al., 2011).

Previous studies have investigated university-industry collaboration within a range of approaches and concepts. Some have studied how science has contributed to technological development by showing how scientific information influences innovation. Others have studied patenting and intellectual property rights related to university-industry collaboration. Still others have studied journal publication output and the effect of researcher-industry involvement on research productivity by focusing on the concept of academic entrepreneurship (Perkmann and Walsh, 2009). Research has also emphasized the contribution of university-industry collaboration

regarding knowledge transfer (Cohen et al., 2002). The concept of absorptive capacity is emphasized in research on university-industry collaboration (Tether and Tajar, 2008) and is found to be a prerequisite for knowledge transfer (Gertler, 1995). Absorptive capacity is most widely defined as a “firm’s ability to recognize the value of new, external information, assimilate it, and apply it for commercial ends” (Cohen and Levinthal, 1990, p. 128). Zahra and George (2002) offer a second definition of absorptive capacity as “a dynamic capability pertaining to knowledge creation and utilization that enhances a firm’s ability to gain and sustain a competitive advantage” (p. 185). Further, Zahra and George (2002) also distinguish between potential absorptive capacity, which concerns knowledge acquisition and assimilation, and realized absorptive capacity, which involves knowledge transformation and exploitation. These authors then suggest that firms’ with similar levels of potential absorptive capacity may differ in their level of realized absorptive capacity depending on their use of social integration mechanisms. Social integration mechanisms facilitate the sharing and exploitation of knowledge and allow firms to realize their potential absorptive capacity through increased information sharing and accumulation and new knowledge transformation (Zahra and George, 2002).

To understand the research debate on social integration mechanisms in the context of university-industry collaboration, I conducted a systematic literature search in the Web of Science research database, which is a platform that helps researchers find, analyze, and share information on the sciences, social sciences, arts, and humanities (Reuters, 2014). First, a broad search covering the overall concepts related to the topic of this thesis, university-industry collaboration and innovation, as well as relevant synonyms, was used to secure relevant results. This led to identifying the following search terms: (universit* or academ*) and (industr* or firm* or compan* or corporat*) and (collabor* or cooperat) and innovat*. The aim of this search was to find articles concerning the phenomenon of this thesis and not to include other theoretical perspectives that might be relevant, such as open

innovation, inter-organizational learning, in addition to the perspective for this thesis, social capital and proximity dimensions.

Next, the research area² in Web of Science was refined to cover only management articles. Then, to secure high-quality articles, the selection of journals was limited to articles published in journals with an impact factor over 1 based on the annual Journal Citation Reports (JCR), which is a measure of the frequency with which the “average article” in a journal has been cited for two years (Reuters, 2014). Based on these search limitations, 206 articles were retrieved. The entire abstract of each article was then read to find the articles of special relevance to my research question. Several articles concerned aspects of university-industry collaboration that were not relevant to this thesis, such as institutional structures and intellectual property rights (IPR), tension related to IPR and patenting, regional economic policies, and commercialization of innovation from university-industry collaboration. Other studies have contributed to the literature on university-industry collaboration by focusing on how university faculties engage in university-industry collaboration, how researchers’ careers develop, and how activities in university-industry collaborations are coordinated and controlled.

Finally, I ended up with 21 articles (see appendix A) related to my research question on how firms develop social integration mechanisms in university-industry collaboration. These articles were read thoroughly to investigate the theoretical debate related to my research question. I then categorized the key findings from the 21 articles related to success factors in university-industry collaboration, and these factors are summarized in Table 2-1.

² Literature searches in Web of Science can be refined to specific research areas (e.g., business economics, engineering, management) (Reuters, 2014).

Table 2-1 Success factors in university-industry collaboration

Success factors in U-I collaboration	Key findings
Structure	<p>Prior collaboration promotes trust in university-industry collaboration (Bruneel et al., 2010, Lhuillery and Pfister, 2009)</p> <p>Prior contacts facilitate new university-industry collaborations (Hong and Su, 2013).</p>
Geography	<p>Face-to-face contacts between industry and academia that are initiated through personal relations and sustained by repeated contact and that involve different channels leading to interaction (Bruneel et al., 2010, Plewa et al., 2013).</p> <p>Real-time contact between technology experts from the partner organization facilitates successful acquisition of technological knowledge (Sherwood and Covin, 2008).</p> <p>Geographical proximity is crucial for assessing problem solving as an important benefit (Bishop et al., 2011).</p> <p>Geographic proximity plays a role in initializing knowledge transfer (Santoro and Gopalakrishnan, 2000).</p> <p>Collaborative partners can be geographically distant as long as they share a common knowledge base on a specific practice at the beginning of the collaboration (Hussler and Ronde, 2007).</p> <p>For collaborative partners with different goals and knowledge bases, geographical proximity is required. Hence, cognitive proximity allows spatially distant collaboration (Hussler and Ronde, 2007).</p> <p>Geographic distance is an obstructive factor in achieving university-industry collaborations (Hong and Su, 2013).</p> <p>Successful U-I collaborations tend to occur between distant partners and geographical proximity is not considered a requirement for university-industry collaboration (Petruzzelli, 2011).</p>
Size	<p>Greater firm size reduces the risk of innovation problems (Lhuillery and Pfister, 2009).</p> <p>Larger firms are most likely to collaborate with PROS (Fontana et al., 2006).</p> <p>Size does not matter for knowledge transfer (Santoro and Gopalakrishnan, 2000).</p>
Culture	<p>Cultural differences can act as a barrier to the transfer of technological knowledge if they are not properly addressed during the collaboration (Bjerregaard, 2010).</p> <p>Mission-oriented and stable cultures with a common sense of purpose are important for managing knowledge transfer in university-industry collaboration (Santoro and Gopalakrishnan, 2000).</p> <p>Cultural differences have some positive effects on the development of competence trust. Goodwill trust evolves through repeated collaborative relationships (Davenport et al., 1999).</p>

Content	<p data-bbox="151 235 207 1948">Knowledge Some similar competencies and capabilities between firms and research partners are important for successful university-industry collaboration. However, too much similarity may be harmful because complementary knowledge is required for innovation development (Petruzzelli, 2011).</p> <p data-bbox="247 235 303 1948">Heterogenic knowledge bases between firms and university partners (Fontana et al., 2006). Strong knowledge bases of the firms will be 'valuable', as they will increase the potential for diffusing knowledge produced by the industry (Giuliani and Arza, 2009).</p> <p data-bbox="343 235 367 1948">Technological relatedness was negatively associated with exploration. Exploration is applied by knowledge from more distant sources (Bierly et al., 2009).</p> <p data-bbox="406 235 446 1948">Trustful relationships Successful U-I collaborations tend to occur between distant partners and geographical proximity is not considered as a requirement for university-industry collaboration (Petruzzelli, 2011). Trust affects successful acquisition of tacit knowledge (Sherwood and Covin, 2008).</p> <p data-bbox="502 235 558 1948">Building trust requires long-term investment in interactions between academics and industrial practitioners, based on mutual understanding about different incentive systems and goals (Bruneel et al., 2010).</p> <p data-bbox="598 235 622 1948">Trust reduces cognitive distance and increases absorptive capacity between partners in university-industry collaboration (Gubbins and Dooley, 2014).</p> <p data-bbox="662 235 686 1948">Trust and contracts can be used as tools to build mutual understanding in asymmetric R&D collaboration (Blomqvist et al., 2005).</p> <p data-bbox="726 235 750 1948">The trust built in prior collaborations engenders social proximity that is strong enough to cancel out the negative effect caused by spatial distance (Hong and Su, 2013).</p> <p data-bbox="790 235 813 1948">Understanding Mutual understanding is important for successful university-industry collaboration (Plewa et al., 2013, Bruneel et al., 2010).</p> <p data-bbox="853 235 877 1948">Understanding the emotional side is the key to achieve successful R&D collaboration (Blomqvist et al., 2005).</p> <p data-bbox="917 235 941 1948">Respect Mutual respect for the use of the scientific method to solve problems is important (Wright, 2008).</p> <p data-bbox="981 235 1005 1948">Belonging to a group reduces the risk of collaborative innovation problems (Lhuillery and Pfister, 2009).</p> <p data-bbox="1045 235 1069 1948">Commitment Firms' R&D commitments influence the benefits from interactions with universities (Bjerregaard, 2010).</p> <p data-bbox="1109 235 1133 1948">The key factor in collaboration is learning by interacting; thus, by being part of the knowledge creation process, the prospects for both scientific inventions and industrial innovations are established (Hameri, 1996).</p> <p data-bbox="1173 235 1197 1948">Social capital Firms collaborating with university researchers with more social capital have higher potential for technology development (Wang and Shapira, 2012).</p>
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2.3. Gaps in the literature on university-industry collaboration

According to Perkmann and Walsh (2007), the effects of links between firms and PROs on innovation are extensively studied, whereas the organizational dynamics underlying these relationships remain under-researched. As illustrated in Table 1, previous studies have identified factors that are important for enhancing valuable university-industry collaboration. For instance, trustful relations, similar culture, prior contacts, mutual understanding and geographical proximity are considered to be requirements for successful university-industry collaboration to develop innovations.

However, the results of the systematic literature search in which only 21 relevant articles were identified illustrates that research on what makes university-industry collaborations valuable is limited and that the focus of articles that respond to the gap identified by Perkmann and Walsh (2007) on the underlying dynamics of university-industry collaborations is narrow. In addition, an in-depth investigation of these papers reveals the limited use of specific theoretical frameworks, and the current literature seems relatively fragmented in the sense that the contributions of these papers do not create a robust literature on university-industry collaboration because the findings do not build directly on one another.

By using the theoretical concepts of social capital and proximity dimensions, this thesis seeks to strengthen the literature on the use of those social integration mechanisms in university-industry collaboration, which likely will facilitate the ability of further research to build on this literature. This thesis thus responds to several calls for in-depth research into the factors that make university-industry collaboration successful. Giuliani and Arza (2009) call for more research on factors that make university-industry collaboration valuable in lieu of research on university-industry collaboration “per se”. Smith (2012) calls for a greater understanding of the innovation process, social interactions and knowledge creation in the university-industry collaboration. Further, Bruneel et al. (2010) suggest that research should examine the factors that lower collaborative barriers over time.

My thesis responds to these research gaps by contributing to a more nuanced theory of *how* firms use PROs as collaboration partners in university-industry collaboration in the development of innovations, which requires a more nuanced understanding of the micro-level mechanisms involved in university-industry collaboration, such as individuals, processes, structures, and their interactions (Felin et al., 2012). This thesis thus develops theory regarding the underlying organizational relationships in university-industry collaboration through the development of social integration mechanisms, which are widely considered to influence organizational behavior and effectiveness (Granovetter, 1985). Research based on quantitative data has offered valuable insights regarding the factors that determine firms' abilities to source external knowledge and the consequences of such knowledge sourcing for firms' innovative and economic performance. Focusing on social integration mechanisms, this thesis investigates how firms can actually benefit from external knowledge sourcing—a topic on which previous research is rather silent, particularly in the context of high dissimilarities between a focal firm and its R&D alliance partner (Smith, 2012).

2.4. Social integration mechanisms in university-industry collaboration

Two theoretical concepts that offer deep insights into social integration mechanisms are social capital and proximity dimensions. Different dimensions of social capital, such as structural, cognitive, and relational social capital, may be important for firms to be able to accumulate knowledge in university-industry collaboration (Nahapiet and Ghoshal, 1998, Inkpen and Tsang, 2005). The structural dimension reflects the *formal structure* of university-industry collaborations, whereas the cognitive and relational dimensions focus on the *content* of the connections (Adler and Kwon, 2002). All three dimensions of social capital have been found to be important for knowledge transfer in university-industry collaboration (Van Wijk et al., 2008). Zahra

and George (2002) explain the social capital concept as a social integration mechanism through which firms realize their potential absorptive capacity. In addition to social capital, this thesis includes the concept of proximity to provide a deeper understanding of what social integration mechanisms are and how these mechanisms are developed in university-industry collaboration. The proximity concept has been used to develop a fine-grained framework for understanding the different advantages that might arise from similarities between collaborative actors that influence interaction and knowledge accumulation among partners in university-industry collaboration (Boschma, 2005; Knobens & Oerlemans, 2006).

Social capital and proximity dimensions are useful in studying how firms develop social integration mechanisms in university-industry collaboration to foster firm innovations because these concepts make it possible to search for nuanced and detailed patterns of social integration among collaborative partners. This thesis explores why some firms are more capable than others at overcoming collaborative challenges and at assimilating and applying novel information from dissimilar collaborative partners (Ambos et al., 2008). Social capital and proximity dimensions combine to form a fine-grained framework for understanding how firms can overcome collaborative challenges because they contain different dimensions that can help identify the content of university-industry collaborations. Table 2-2 summarizes the concepts of social capital and proximity dimensions and illustrates that the concepts adopted emphasize different levels of analyses and originate from different backgrounds.

Table 2-2 The origin of proximity dimensions and social capital

Theoretical approaches	Proximity dimensions	Social Capital
Background	Regional industrial and economic geographical theory	Sociological and economic theory
Level of analysis	Mainly macro level, such as regions, but increased focus on organizations and individuals	Mainly individuals, but also organizations and nations
Main focus	Regions (national, regional), industrial districts	Individual interaction, social structures
Dimensions included in this thesis	Social, cognitive, technological, organizational, institutional, cultural	Structural, cognitive and relational
University-industry collaboration strategies	Understands factors behind the process of interaction and knowledge transfer	Social relations as drivers for inter-organizational collaboration
Key work	Boschma (2005); Knoblen and Oerlemans (2006); (Broekel and Boschma, 2012)	Nahapiet and Ghoshal (1998); (Adler and Kwon, 2002); Inkpen and Tsang (2005)

2.4.1 Proximity dimensions

The concept of proximity originates from regional industrial studies focusing on the characteristics, conditions and features of industrial districts (Shaw and Gilly, 2000). “Proximity” is a term that has experienced increased interest in the economic literature, particularly in discussions of space in areas such as districts and techno poles, in which measures of proximity increasingly contribute to economic analysis. Historically, the concept of proximity was used to analyze whether production systems or enterprises should be localized close to or far from other firms, and the “spatial” or “geographical” dimension of proximity thus arose in the literature. Authors have also analyzed the causes of the externalities of geographical proximity, such as personal relations, interaction, communication and information sharing among workers. The importance of geographical proximity to interactive learning and

innovation has been illustrated when groups of localized firms share skills (Shaw and Gilly, 2000). Hence, the geographical proximity dimension is used to analyze personal relations. Further, geographical proximity is used to analyze how innovation concentrates in regions or smaller geographical areas (Feldman, 1994). The link between PROs and firms in geographical proximity is highlighted as important for developing new technologies through collaboration, and there has been increased interest in studying proximity in the innovation process and through links between industry and science (Shaw and Gilly, 2000).

Moreover, the proximity literature has developed a fine-grained framework for understanding different aspects of university-industry collaboration (Knoben and Oerlemans, 2006, Boschma, 2005), in which different types of proximity are suggested in facilitating successful university-industry collaboration (Knoben and Oerlemans, 2006). The proximity concept refers to “being close to something measured on a certain dimension” (Knoben and Oerlemans, 2006, p. 72), and proximity is an important condition for innovation because different types of proximity contribute to interaction and knowledge transfer in different ways (Boschma, 2005). Examining proximity is crucial to understanding the factors behind the process of interaction and knowledge transfer between firms and collaborative partners because proximity promotes trust and understanding when complex and high-risk innovation projects are undertaken (Menzel, 2008).

The proximity concept provides alternative ways to reach the same outcome through different types of proximity, and it is well suited to exploring changes in relationships between collaboration partners over time. Different dimensions of proximity may be important, depending on the characteristics of a firm and on the type and phase of the innovation project; moreover, one dimension of proximity may be a substitute for another, while other dimensions may complement one another. The literature has suggested that many different dimensions of proximity might influence collaboration and innovation (Boschma, 2005). The first article in this thesis

examines the dimensions of social, cognitive, institutional, cultural, technological and geographical proximity, which are considered particularly relevant to inter-organizational collaboration (Knoben and Oerlemans, 2006), and the second article is in line with Broekel and Boschma (2012), who have examined the role of geographic, cognitive, social, and organizational proximity in innovation performance.

Social proximity is generated through relationships between actors that are social in that they involve trust, friendship and common experiences (Boschma, 2005). Social proximity is critical to collaborative innovation performance (Ben Letaifa and Rabeau, 2013) because it facilitates effective communication that is important for knowledge transfer between collaborative partners (Maskell and Malmberg, 1999). Social proximity is often generated by past collaborations and repeated contact between partners in which reputation and trust are created (Balland, 2011).

Cognitive proximity refers to the similarities between the ways in which actors perceive, interpret, understand and evaluate the world (Wuyts et al., 2005), and it facilitates effective communication and new knowledge absorption (Boschma, 2005). Actors must have similar frames of reference to manage effective communication and thereby manage knowledge transfer (Knoben and Oerlemans, 2006). Sharing a common knowledge base and expertise may facilitate the accumulation of knowledge between actors in university-industry collaboration (Nooteboom, 2000).

Whereas social proximity relates to relations on a micro level, *institutional proximity* relates to the institutional framework on a macro level, such as when collaborative partners face common laws and norms. Institutional proximity thus affects how organizations coordinate their actions (Knoben and Oerlemans, 2006). Institutional proximity is defined as a 'set of common habits, routines, established practices, rules, or laws that regulate the relations and interactions between individuals and groups' (Edquist and Johnson, 1997, p. 46).

Cultural proximity refers to similarities in organizational cultures. Similar organizations are expected to interact more easily and achieve better results because

common interpretations and routines allow organizations to interpret and give meaning to actions without having to make difficult interpretations explicit (Knoben and Oerlemans, 2006).

Technological proximity refers to the extent of shared knowledge bases and experiences between collaborative partners related to technology development. This type of proximity refers to the knowledge that actors gain from the process of developing technologies, rather than technological knowledge per se (Knoben and Oerlemans, 2006). Firms may better accumulate knowledge through technological intermediaries via knowledge activities such as gate keeping, technology watch and road mapping (Spithoven et al., 2011). Technological proximity can be viewed on a general and a dyadic level: the new knowledge must be generally similar to a firm's prior knowledge but must include new and specialized knowledge at a dyadic level (Knoben and Oerlemans, 2006).

Geographical proximity facilitates university-industry collaboration (D'Este et al., 2012) and relates to territorial, spatial, local or physical closeness (Broekel and Boschma, 2012). Small geographical distances facilitate face-to-face interactions, which promote the knowledge transfer and innovation (Knoben and Oerlemans, 2006). It is easier to interact when actors are co-located, even temporarily—for instance, during conferences and business meetings (Torre, 2008).

Organizational proximity refers to shared relations within or between organizations, and it is advantageous to innovation networks (Boschma, 2005). This dimension of proximity is supported by common rules and routines in organizations (Torre and Rallet, 2005). There is arguably a significant amount of organizational distance between industrial firms and PROs. Firms and PROs have different purposes and experiences, and there may be significant tensions between academic and commercial orientations. Organizational proximity refers to the closeness among firms within the same corporate group (Boschma, 2005). When the level of

organizational proximity is high, organizations are more likely to interact (D'Este et al., 2012).

Authors have begun to explore how different dimensions of proximity interplay and overlap with one another. Geographical proximity is of special importance when firms lack social proximity because face-to-face interaction can facilitate social relations (Cassi and Plunket, 2013) and can positively influence mutual trust between collaborative partners (Ponds et al., 2007), thereby building social proximity. Geographic proximity also plays an important role in building cognitive, institutional and cultural proximity, as being close to collaborative partners provides a common understanding, cultural similarities and norms through interaction (Boschma, 2005). Geographical proximity has also been found to overlap with cognitive and technological proximity because it is easier to collaborate with local actors (Broekel and Boschma, 2011). Social proximity and geographical proximity are mutual substitutes in the sense that geographical distance may be compensated through personal closeness and vice versa (Cassi and Plunket, 2013). Cognitive proximity and geographical proximity are also found to have overlapping effects because having shared understandings and a common language may help firms overcome challenges related to geographical distances and vice versa (Broekel and Boschma, 2011). Moreover, social proximity may build cognitive proximity because knowing one another facilitates increased common understanding (Ben Letaifa and Rabeau, 2013).

The literature emphasizes the many advantages of being close to collaborative partners because such closeness facilitates interactive learning and knowledge accumulation. However, too much proximity may be harmful for learning and innovation (Boschma, 2005). If collaborative partners are too geographically proximate, it may reduce the firms' flexibility in responding to new developments in more distant areas (Boschma, 2005). Because knowledge transfer in university-industry collaboration requires complimentary knowledge bases, cognitive proximity may weaken firms' abilities to learn from their collaborative partners if it reaches a

very high level (Boschma, 2005), and it may prevent firms from exploiting new knowledge (Nooteboom, 2000). Moreover, too much social proximity may induce firms to neglect potentially unknown partners with relevant knowledge (Boschma, 2005), and closed communities of people may lead to opportunistic behavior by calculating actors (Ben Letaifa and Rabeau, 2013).

2.4.2 Social capital

The concept of social capital originates from sociological studies, and it is a popular concept for explaining and understanding how involvement and participation in groups positively influences individuals as well as nations (Portes, 2000). Social capital is defined by Bourdieu (1986) as “...the aggregate of the actual or potential resources which are linked to possession of a durable network of more or less institutionalized relationships of mutual acquaintances and recognition—or in other words, to members in a group” (p. 248). Derived from economic capital, social capital acts as secondary costs that one cannot directly access. Some goods can be acquired only through secondary costs, such as social relationships, which cannot be “paid” for directly but must be developed over time for their own “relational” sake, rather than just for the period during which they are utilized (Bourdieu, 1986). In contrast to other forms of capital, such as the human capital inside people’s heads and the economical capital in people’s bank accounts, social capital relates to other individuals (Portes, 2000). Social capital is focused on the positive consequences of sociability and is developed into a framework in which the positive consequences of sociability is raised to a broader discussion of capital and the value of nonmonetary capital, such as financial capital. At this juncture, the path of social capital meets the path of economic research.

Scholars have broadly conceptualized social capital and the benefits regarding social capital derived from social structures, and researchers vary in their views and

level of analysis of the concept. One body of literature views social capital as a public good, focusing on social capital at a macro level, such as the level of communities and nations (Portes, 2000, Putnam, 1993). Putnam (1993) describes social capital as facilitating effective collaboration, effective regulation and positive social behavior in communities through trust, reciprocity and strong social norms. For example, Putnam (1995) shows that the decline in civic engagement in the USA has decreased social connectedness among Americans. Social capital is thus beneficial for all members within a community. Other scholars adopt a private-good view of social capital that examines how individuals can benefit from social capital (Shaw et al., 2005) and how individuals with several exchange relations achieve greater benefit than more disconnected partners (Burt, 2000). Traditionally, social capital has been examined in micro- and macro-level studies, but the concept has recently been extended to the organizational level (Tsai and Ghoshal, 1998, Tsai, 2002) to show how firms can benefit from social capital. For example, Nahapiet and Ghoshal (1998) show how social capital facilitates firms' intellectual capabilities.

This thesis focuses on the individual and organizational level of social capital to explore how social integration mechanisms are developed in university-industry collaboration and therefore follows a more recent definition of social capital that affects firms' abilities to transfer knowledge within networks: "the aggregate of resources embedded within, available through, and derived from the network of relationships possessed by an individual or organization" (Inkpen and Tsang, 2005, p. 151). In this view of social capital, the network of relationships is valuable for both individuals and firms, and firms should proactively build social capital to achieve effective knowledge transfer in university-industry collaboration (Inkpen and Tsang, 2005). Thus, the individual and organizational levels of social capital are often interrelated. For instance, members of a network can benefit from organizational social capital without necessarily having participated in the network or having developed the social capital (Kostova and Roth, 2003), and individuals in an

organization can develop relations with other individuals and organizations and can thus create organizational social capital on the basis of individual social capital (Inkpen and Tsang, 2005). Further, social capital can be viewed from a bridging perspective or a bonding perspective. The bonding view of social capital focuses on the internal characteristics of collective actors, where the network encompassing these actors can be an organization, community or nation. The bridging view perceives social capital as a source to enhance links among networks through external relations (Adler and Kwon, 2002).

This thesis adopts a social capital framework derived from Nahapiet and Ghoshal (1998), which is categorized as structural, cognitive and relational social capital. All these dimensions are important for university-industry collaboration, with relational social capital as the strongest driver (Van Wijk et al., 2008).

Structural social capital focuses on advantages related to actors' networks of contacts and relates to linkages between people and organizational units, which can be considered an overall pattern of connections showing who actors are and how actors reach one another (Burt, 1992); it concerns the importance of network configurations and ties between actors in the innovative process (Ahuja, 2000, Powell et al., 1996). The structural dimension of social capital is important for knowledge transfer because network ties enhance learning for all the actors in the network and reduce their competitive attitude toward learning and innovation (Inkpen and Tsang, 2005). Firms with central network positions increase accumulated knowledge for collaborative partners, while firms in equivalent positions gain less value from structural embeddedness (Van Wijk et al., 2008). Factors that strengthen ties include prior and repeated contacts between actors (Gulati, 1995).

A mutual lack of understanding about working practices and expectations is found to be a barrier to university-industry collaboration (Bruneel et al., 2010), and building *cognitive social capital* may be one path for firms to overcome this challenge and to accumulate knowledge. Cognitive social capital refers to shared

interpretations and systems of meanings (Cicourel, 1974), common language and codes (Monteverde, 1995), and shared narratives (Orr, 1990) among parties. When organizations have shared visions and systems, it is easier for them to learn from one another (Hult et al., 2004). Cognitive social capital has been divided in two categories: shared goals and shared culture (Adler and Kwon, 2002). Shared goals refer to a common understanding and approach concerning network tasks (Inkpen and Tsang, 2005) and common perspectives regarding goals (Masiello et al., 2013). Previous research shows that successful collaboration between firms and PROs is closely associated with similarity in competencies and capabilities (Petruzzelli, 2011). Shared culture refers to rules and norms that determine appropriate behavior in a network. When actors within a network have cultural linkages, it is easier for them to collaborate with one another (Inkpen and Tsang, 2005). However, excessive cognitive similarity may reduce the creation of innovation in inter-organizational collaboration, and an inverted U-shape relationship exists between cognitive social capital and innovation in collaborative innovative performance (Cowan et al., 2007).

Relational social capital focuses on relational closeness and trust and refers to “those assets created and leveraged through relationships” (Nahapiet and Ghoshal, 1998, p. 258); it describes personal relationships formed through prior contacts (Granovetter, 1992) and concerns mutual respect and friendship, expectations and reputations (Adler and Kwon, 2002). Prior experience in collaboration is found to positively affect university-industry collaboration (Hagedoorn and Schakenraad, 1994). Petruzzelli (2011) finds that the existence of previous collaborations promotes trust between academic and industrial partners, illustrating the usefulness of building personal relations in developing technology. Relational social capital is found to be the most important dimension of social capital as a driver for university-industry collaboration because of the importance of trust in such collaboration (Van Wijk et al., 2008). Because university-industry collaboration often involves collaboration between unknown partners and thereby a high level of uncertainty (Bruneel et al.,

2010), building trust through personal relations can reduce uncertainty among collaborative partners and increase their willingness to be open and to share information and resources (Adler and Kwon, 2002, Tsai, 2000). Moreover, building trust with collaborative partners may reduce the risk of opportunistic behavior (Putnam, 1993). Conversely, Yli-Renko et al. (2001) argue that when trust reaches a very high level, it can be detrimental to university-industry collaboration because the need for control perceived by actors, the level of conflicts among actors, and the extent of efforts to persuade other actors may diminish, which may hinder the creation of new knowledge (Masiello et al., 2013).

All three dimensions of social capital can play an important role in university-industry collaboration. Structural social capital may be required to gain access to networks that contain valuable and diverse knowledge for a firm, and relational and cognitive social capital may facilitate effective knowledge transfer (Van Wijk et al., 2008). However, social capital can also have negative consequences. A high level of social capital can improve creativity and idea generation because social capital may limit firms' access to diverse sources of new knowledge (Nahapiet and Ghoshal, 1998). Researchers have also explored the interplay between the different dimensions of social capital. For example, actors with strong symmetrical ties might be associated with trustworthy interpersonal relations (Granovetter, 1985). The interdependency between shared language (cognitive social capital) and social relations (relational capital) has also been emphasized (Ashforth and Mael, 1996). Moreover, not all the dimensions of social capital are mutually dependent. A network consisting of strong structural ties may not contribute to cognitive and relational social capital, which enables effective operation (Nahapiet and Ghoshal, 1998). The next section provides a conceptual framework for this thesis.

2.5. Conceptual framework

Based on the overall research question and discussion of the theoretical concepts used in the thesis, Figure 2-1 presents a conceptual framework that integrates the different concepts.

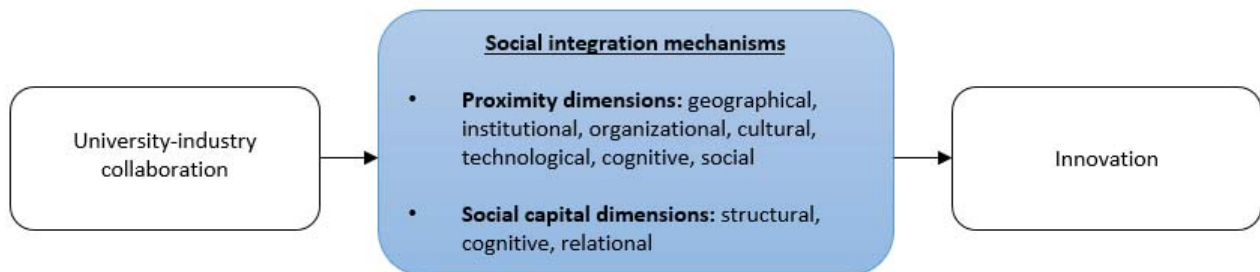


Figure 2-1 Innovation process of university-industry collaboration

To answer the overall research question (i.e., *“How are social integration mechanisms developed in university-industry collaboration to foster firm innovations?”*), this thesis explores social integration mechanisms that are likely to influence the *process* leading to innovations. The theoretical concepts of social capital and proximity dimensions are used to examine the collaborative process because these concepts focus on interaction between collaborative partners and are thus suitable for an in-depth investigation on the organizational dynamics underlying university-industry collaboration, as called for by Perkmann and Walsh (Perkmann and Walsh, 2007). Developing theory regarding the development of social integration mechanisms in university-industry collaboration through social capital and proximity dimensions will likely improve our understanding of how university-industry collaboration facilitates knowledge acquisition and innovation development in firms. Hence, this thesis provides important theoretical contributions and implications for firms, PROs and policy makers regarding how social capital and proximity dimensions can be developed in university-industry collaboration to foster firm innovations.

3. Methodology

3.1 Introduction

This chapter presents the methodological approach that is used to examine and answer the research questions of this thesis. First, the philosophy of science is discussed, and a discussion of the research design, research process, data collection and data analysis follows. Finally, the quality of the data, critical reflections on the methodology and ethical considerations are considered.

3.2 Philosophy of science

In the following sections, I will reflect on my research questions in relation to the philosophy of science, which according to Gilje and Grimen (2004, p. 11) is a “...*systematic study of scientific activity and knowledge. It is one of several disciplines that make scientific activity and knowledge to the subject of study*”. The term “paradigm” is often used within philosophy of science to explain different scientific approaches, which can be considered common frameworks consisting of theories, understandings, values and techniques that the participants of a certain scientific group use (Johnson and Duberly, 2000). Different paradigms view the world differently and consist of various elements, including ontological, epistemological and methodological elements (Denzin and Lincoln, 1994). Ontological elements consider understandings regarding the reality of the world. Epistemological elements consider how knowledge about reality is acquired (Johnson and Duberly, 2000). Methodological elements address how knowledge about the world can be generated through research—such as, for example, through data collection techniques and analysis (Easterby-Smith et al., 2008).

This thesis aims to develop a deeper understanding of how social integration mechanisms are developed in university-industry collaboration to foster firm innovation by investigating interactions between collaborative partners. Two scientific approaches focus on in-depth understandings of social processes between people: social constructionism and hermeneutics. This thesis is primarily influenced by social constructionism paradigm but is inspired by elements of the hermeneutic paradigm. According to Talja et al. (2005), a researcher's work cannot be expected to consistently rely on only one research paradigm. Accordingly, I have one foot in the social constructionism paradigm and the other foot in the hermeneutic paradigm. In the following discussion, the positivistic paradigm is used for purposes of contrast.

3.2.1 Social constructionism

Social constructionism developed as a reaction to the positivistic view of science that adopts an ontological understanding on the world (i.e., both natural and social) in which the world has an external existence and must be explored through objective methods (Easterby-Smith et al., 2008). By contrast, social constructionist claim that individual and social phenomena should be explored through individuals' subjective minds rather than through their observable behavior. Social constructionism is based on a hermeneutic tradition in which knowledge is created through individuals' subjective and inter-subjective interpretations of reality. In this view, "man" and "reality" are considered inseparable, and thoughts and actions result from an ongoing interpretation process among people (Lindgren and Packendorff, 2009). Conversations are central in the social constructionism paradigm, and if these ideas are transferred to this thesis, the collaborative partners within university-industry collaboration collectively produce the reality of the collaboration through language and a two-way process of communication (Talja et al., 2005). Following the social constructionist view, this thesis aims to understand how individuals construct social interaction in university-industry collaborations to develop innovations.

3.2.1.1 Ontological position

The ontological position of social constructionism is that reality is socially constructed and given meaning by people rather than objective and external. Social constructionism posits the community-generated nature and understanding of reality, knowledge, thoughts, facts, texts, etc. (Bruffee, 1986). Social constructionism implies that people construct and understand their reality and actions through social processes (Cunliffe, 2008). If these ideas are applied to university-industry collaboration, collaboration is socially constructed and subjectively understood by the individuals who give the collaboration meaning in the exchange and development of knowledge.

The social constructionist approach moves from a positivistic notion of “reality” as objective and exterior to the notion of “reality” as socially constructed. Researchers within the positivistic approach are looking for cause and effect in a phenomenon—so-called causality—which often is used in natural science, where cause-effect relations are observed and measured. One problem related to cause-effect relations in social science is that the focus can be exceedingly narrow (Johnson and Duberly, 2000). A narrow focus is often the goal in natural science to facilitate the development of new theories, but in social science, the goal is rather to understand a phenomenon and happenings in terms of larger relations. In the social constructionism paradigm, action is the result of understanding in different situations rather than a direct response to stimuli, which is central to positivism. In the social constructionism, the focus is on what people think and feel individually and collectively, and attention is directed toward the way that they communicate—verbally and non-verbally. Social constructionists seek to understand why people have different experiences rather than to identify external causes to explain behavior, as in the positivistic approach (Easterby-Smith et al., 2008).

If the goal of this thesis were, for instance, to measure the causal effects of the determinants of university-industry collaborations, a positivistic approach and a large sample quantitative study could have been used. Previous studies within the literature on university-industry collaboration have provided a large amount of research on such effects. However, this thesis seeks to provide an in-depth understanding of *how* successful university-industry collaboration can be enhanced by investigating how social integration mechanisms are developed in university-industry collaborations. Thus, this thesis focuses on how the people within university-industry collaborations create meaning by sharing their experiences, which is characteristic of the social constructionism paradigm.

According to Fletcher (2006), social constructionism concerns providing knowledge about reality, and explanations should be derived from relationships. The relational focus in the social constructionist view moves beyond understanding social practice and behavior; it focuses on *relationality* instead of objectivity and subjectivity. The whole of human relations and the social context that they create—as opposed to the individual and private spaces of particular individuals—act as the theoretical starting point. Researchers should therefore look for descriptions, explanations and representations that derive from relationships. People, structures, the physical world, culture, language, words, concepts and images become meaningful in their *relatedness* to one another, not from representations of how the world really is or from the meaning in peoples' minds (Fletcher, 2006). University-industry collaboration concerns social interaction between individuals, and the collaborations in this thesis constitute a type of collaborative social achievement consisting of *relational* links between collaborative firms and PRO partners. The innovations created in the collaborations are likely to result from the interaction between the participants who are engaged in creating meaning in the collaboration.

3.2.1.2 Epistemological position

This thesis aims to understand the complex process of the development of social integration mechanisms in university-industry collaboration to foster firm innovation rather than to quantify why it is important to create university-industry collaborations for innovation development. To acquire knowledge about reality, the social constructionist approach explains knowledge as produced through conversations between people (Easterby-Smith et al., 2008). If positivism were applied to answer my research questions, different variables might be measured to find causal correlations regarding how firms manage successful university-industry collaboration. Several variables are likely to influence the development of social integration mechanisms in university-industry collaboration, and it would be nearly impossible and inexpedient to measure all of these. A social constructionist paradigm, which this thesis emphasizes, would instead imply a descriptive/interpretive investigation of how and why university-industry collaborative processes emerge and how these collaborations are constructed by social interactions between individuals.

Moreover, the social constructionism paradigm focuses on language and communication between people, and research adopting such a paradigm aims to enhance understanding by means of analyzing and giving meaning to the phenomenon (Easterby-Smith et al., 2008). Finally, social constructionists believe that by entering a research field free from any pre-understanding about reality, a complete understanding of how people create structures in their surroundings might be arrived at (Easterby-Smith et al., 2008). Because we all have experiences and knowledge that likely influence our interpretations when researching a phenomenon, I doubt that it is possible to completely neglect my pre-understanding when doing research. Inspired by the hermeneutic research paradigm, I have been conscious of my pre-understandings and have adopted elements from the hermeneutic paradigm in this thesis, as a complement to the social constructionist paradigm.

3.2.2 Hermeneutics

The hermeneutic paradigm focuses on the researcher's interpretation. In the hermeneutic research approach, it is understood that researchers cannot be completely objective and that our pre-understanding influences the way in which we interpret reality. Our pre-understanding influences the manner in which we talk to our informants and influences our analysis (Eide and Lindberg, 2006).

The hermeneutic circle is a central part of the hermeneutical research approach, in which all interpretation is considered to involve movement between different levels—between the totality and the individual, between the subject that should be interpreted and the context, and between the subject that should be interpreted and our own pre-understandings (Johannessen et al., 2005, Johnson and Duberly, 2000). The parts are interpreted and understood from the totality, and the totality is interpreted and understood from the parts. The hermeneutical circle has been central to this research, and I have continuously tried to achieve an understanding of the totality of the studied collaborations. To obtain such an understanding, I have investigated each of the central parts that influence the university-industry collaborations, including the firms, the PROs, the contexts (e.g., the different types of investigated collaborations), and other elements that may influence my understanding of university-industry collaborations (e.g., document materials). By reflecting on how my chosen context differs from other similar context in studies investigating university-industry collaboration, I have also been aware of how the context may have influenced my findings and analysis (Eide and Lindberg, 2006).

The hermeneutic circle involves a research process in which the researcher develops a pre-understanding of the research phenomenon and then enhances that understanding through on-going dialogue with informants (Alvesson and Sköldbberg, 2009). In contrast to the social constructionist approach, the hermeneutic approach realizes that a researcher cannot be completely objective. I have tried to be deeply

aware of my pre-understanding and its potential influence on my interpretation of reality when speaking with informants, particularly when I confronted contrasting understandings and when analyzing my data (Eide and Lindberg, 2006). Fusion of horizon, which means that a process of interpretation will occur in the meeting between a researcher's and an informant's horizons, is central in the hermeneutic approach. Such a process of interpretation may result in a revision of horizons and may occur when a pre-understanding meets resistance (Eide and Lindberg, 2006). In the interviews, I shared my pre-understanding with informants by telling them how I understand different aspects of university-industry collaboration. This may have contributed to a process of knowledge development in which both of us learned something new and where our knowledge thus changed.

3.2.3 Research approach

There are two general approaches to new knowledge acquisition, namely, inductive and deductive. The deductive approach is a theory-testing process in which theoretical assumptions are tested based on specific instances (Hyde, 2000), and the researcher begins by testing his or her expectations about reality with data. One weakness of this approach is that researchers may seek only information that they consider relevant and may leave out other important aspects of the studied phenomenon (Jacobsen, 2005). The inductive approach is a theory-building process that begins with observation in a research field followed by generalization (Hyde, 2000). With an inductive approach, the researcher begins by gathering data with an open mind and then moves on to detect general themes in the data (Jacobsen, 2005). The inductive approach is generally used by social constructionists in theory building (Turnbull, 2002), but this thesis adopts aspects from both deductive and inductive approaches; thus, it is more influenced by an abduction process.

The abductive approach begins with data (inductive), but the researcher is influenced by theoretical perspectives before or during the research process (Alvesson and Sköldbberg, 2009). During the research process, I went back and forth between the empirical setting and a theoretical setting. Through initial interviews in the field, I began the process through a so-called inductive, data-driven approach in which the aim was to use the collected data to build theory. Through the interview material, I found some interesting phenomena, which were further investigated with different theoretical approaches that are suitable for exploring social integration mechanisms in university-industry collaboration. Early on, I observed that social closeness and similarities between collaborative partners were central themes in the data collected to that point, which induced me to further investigate the concepts of proximity dimensions and social capital. After reading the literature on these concepts, I conducted the next round of data collection by following a more deductive, theory-driven approach in which the content of the interviewing questions focused on theoretical aspects drawn from the literature on social capital and proximity. However, to ensure that other important aspects related to the studied phenomena as a totality were not omitted, open-ended questions were used in interviews such that the theoretical concepts were not explicitly articulated.

3.3 The case study design

A research design explains how data are gathered and analyzed to answer a research question, and a case study design is chosen for this study because such design is suitable for building theory in research fields with less defined frameworks and variables (Yin, 2009). When conducting this case study, I was mainly inspired by the work of Eisenhardt (1989) and Yin (2009), who are considered pioneers in the case-study tradition because they have well-developed frameworks for theory building in case studies.

Case studies focus on understanding the dynamics of single settings (Eisenhardt, 1989), and such a research design involves studying one or more cases over time through a detailed and comprehensive data collection process (Johannessen et al., 2005). Merriam (2004) notes four main characteristics that are central to a case study. First, the case should reflect on a situation, happening or phenomenon, and the result of a case study should be a complete description of the studied phenomenon. It is also important that a case study increase the understanding of a phenomenon and offer possibilities to develop new knowledge. My thesis aims to do this by building theory regarding how social integration mechanisms are developed in university-industry collaboration to foster firm innovations, which is a field that calls for more in-depth research.

The case study approach was chosen for my research for several reasons. First, a case study is a suitable research strategy to obtain a detailed and complete picture of social phenomena (Yin, 2009), such as social integration mechanisms in university-industry collaboration. Second, my research addresses a defined social setting, whereas quantitative research often studies a variety of settings to increase the generalizability of the results (Miles and Huberman, 1994). Third, my research question seeks to explain certain circumstances that are present, and it thus starts with a *how*, which according to Yin (2009) should be one of the reasons for choosing a case study as a research strategy. Further, the research question in this thesis is explanatory in nature, seeking to explain how some firms rather than others manage to accumulate knowledge from university-industry collaborations and to generate innovations (Yin, 2009). In addition, case studies often must be conducted over time rather than obtaining data with higher frequency or more incidents (Yin, 2009). This thesis has been developed over a number of years, which made it possible to conduct a longitudinal study, which is used for two of the data sets included in this thesis.

Finally, the behavior within the studied university-industry collaborations cannot be controlled and was not able to be manipulated by me as a researcher (Yin,

2009). Even if I cannot control the actors' behavior, when I maintain the hermeneutic approach in my mind and am aware of my pre-understanding, I can avoid obtaining false information about how the actors are behaving to facilitate collaboration. Depending on the research question, researchers can adopt either a single-case or a multiple-case study (Yin, 2009). For this thesis, a multiple-case study was chosen to provide robust results and to facilitate the ability to look for similarities and differences across cases. First, I began with a research focus and an initial research question, which changed as I gained knowledge based on theory and the collected data, and I then selected the cases, performed the data collection, and analyzed and compared these findings with findings from the previous literature and developed propositions (Eisenhardt, 1989). Table 3-1 illustrates the methodology used for each paper in this thesis.

Table 3-1 Methodology used in the papers

Paper title	Unit of analysis	Type of study	Case selection
1. The role of proximity dimensions in increasing firms' absorptive capacity in a cooperation alliance: a longitudinal case study	Relationships among the firms' representatives within a cooperation alliance	Comparative case study	5 firms within a cooperation alliance
2. How firms collaborate with public research organizations: the evolution of proximity dimensions in successful innovation projects	Innovation projects and the relationships among the firms and the PRO participants within the projects	Comparative case study	15 innovation projects
3. The interplay and evolution of the dimensions of social capital in open innovation	Innovation projects and the relationships among the firms and the PRO participants within the projects	Comparative case study	15 innovation projects
4. How Social Capital Mitigates Collaboration Challenges in University-Industry Research Alliances: A Longitudinal Case Study	Research alliances and the relationships among the participating firms and PROs within the alliances	Comparative case study	6 firms within 2 research alliances

3.3.2 Empirical setting

The empirical setting of this thesis consists of research programs supported by the Research Council of Norway as an instrument to support R&D and innovation. To provide variety in the studied context (Yin, 1989), three research programs were selected to comprise the empirical setting of university-industry collaboration: user-driven innovation projects (the BIPs), the FFF and the FMEs. These three types of university-industry collaboration are chosen to explore the development of social integration mechanisms because each entails R&D collaboration for innovation among firms and PRO partners. The programs nevertheless have some differences, which provides me with an opportunity to investigate similarities and differences across the types of collaboration. Table 3-2 summarizes information regarding the objective, participants, funding and establishment of each collaboration type.

Table 3-2 Empirical setting of this thesis

Collaboration	Objective	Participants	Funding	Establishment
User-driven innovation projects (BIPs)	A public support scheme that supports high-potential innovation projects in Norwegian firms and that stimulates R&D	Each project was managed by a lead firm and always included at least one research institution—and often other firms—as a partner.	Research grants from The Research Council of Norway (20-40%) and financing from the firm\	BIPs were established in the 1990s by The Research Council of Norway
The Norwegian Ferroalloy Producers Research Association (FFF)	To pursue environmental improvements and to increase the technological qualifications of the employees within the industry	All firms within the Ferro-alloy industry in Norway and their external R&D partners as participants and as hosts for each project (mainly universities and public research organizations)	Research grants from The Research Council of Norway (30-50%) and participation fees from member companies	FFF was established by the industry in 1989
Centers for Environment-friendly Energy Research (FMEs)	International long-term research to solve specific challenges in the energy industry and new innovative solutions	A university, university college or research organization as a host for each project, with firm partners covering large parts of each branch of the value chain, and occasionally other research organizations	Research grants from The Research Council of Norway (50%) and financing from the member companies (25%) and research partners (25%)	FMEs were established by research organizations in 2009

User-driven innovation projects (BIPs)

User-driven innovation projects—called BIPs—constitute a public support scheme established by the Research Council of Norway in the 1990s that supports high-potential innovation projects in Norwegian firms. BIPs are one of the most important instruments employed by the Research Council of Norway to stimulate research and innovation in industry through collaboration between firms and PROs (Clausen et al., 2011). The idea behind BIPs was that the users—firms—have more market knowledge

and other knowledge needed to evaluate the potential of innovations than PROs (Bugge et al., 2011). BIPs are financed by research grants from The Research Council of Norway (20-40%) and financing from the applicable firm. The “users” set the premises for the projects, apply for grants for the projects and act as contacts for the research council. The Research Council of Norway has recently increased its support for user-driven research, and the total amount of grants supporting user-driven innovation programs passed one billion in 2009, 619 million of which was given to firms (Forskningsrådet, 2010). BIPs are one of the largest activities within the Research Council of Norway, constituting 16% of the council’s total grants in 2009 (Clausen et al., 2011). In total, 2,924 BIP grants were applied for between 2000 and 2007, and 45.8% received support (Bræin et al., 2009).

The Norwegian Ferroalloy Producers Research Association (FFF)

The Norwegian Ferroalloy Producers Research Association, which is also referred to as the FFF is a cooperation alliance within the ferro-alloy industry that was established by the industry in 1989. This industry faces many environmental challenges because it is one of the most polluting industries in Norway. Given the increasing focus on environmental issues, this industry faces an ever-increasing number of regulations, and firms in the industry must innovate to remain competitive in the global market. The alliance consists of all firms within the ferro-alloy industry in Norway, and it conducts joint research projects on products and processes (Sintef, 2011). The alliance cooperates with external PRO partners, which are included in most of the alliance’s projects. The aim of the alliance is to pursue environmental improvements, conduct research and increase the technological qualifications of employees within the industry. The alliance operates as a non-profit organization, with research activities funded by research grants from the Research Council of Norway (30-50%) and by participation fees from member companies (Sintef, 2011). The alliance is

currently collaborating on four environmental R&D projects. One of the external PRO partners manages each project, and other firms and research institutions are included as partners.

Centers for Environment-friendly Energy Research (FMEs)

The Centers for Environment-friendly Energy Research—also known as FMEs—were established by the Research Council of Norway as a follow-up to a broad political agreement on climate policy in Norway made in 2008 and to the national R&D Energi21 strategy adopted in 2008 by the Norwegian Ministry of Petroleum and Energy. The FMEs seek to develop expertise and promote innovation through long-term research in the field of environment-friendly energy. The FMEs address a broad range of areas that are central to the development of the energy sector. The foci of the eight centers that were established in 2009 are renewable energy, energy efficiency, energy planning and carbon capture and storage, and the three centers that were established in 2010 focus on social science-related energy research (Forskningsrådet, 2011).

The FMEs were established to be funded over a period of eight years, and their objective is to conduct long-term international research to solve specific challenges in the energy sector. Thus, research in the centers is mainly based on new or immature industries with a high need for the development of new environmental knowledge. FMEs encourage firms to innovate by devoting more attention to R&D activities in collaboration with PRO partners. Sometimes, various organizations, such as interest organizations, participate in FME alliances. FMEs are financed by research grants from the Research Council of Norway (50%) and by financing from the member companies (25%) and research partners (25%) (Forskningsrådet, 2011).

By fostering collaboration between firms and PROs, FMEs are expected to contribute to a secure energy future in Norway. However, collaborations sometimes face challenges, and many firm partners have left the centers (Forskningsrådet, 2013).

3.3.3 Case selection

In this thesis, firms and projects are considered cases, which can be defined as “*a phenomenon of some sort occurring in a bounded context*” (Miles and Huberman, 1994, p. 25). As Table 3-1 illustrates, the FFF data set was used for Paper 1, the BIP data set was used for Papers 2 and 3, and the FFF and FME data sets were used for Paper 4.

There is no ideal number of cases, but Yin (1989) suggests using up to 30, whereas Eisenhardt (1989) suggests that 4-10 cases is often suitable. Moreover, for social constructionist researchers, a large number of cases is typically not needed or desirable (Turnbull, 2002). Following Yin (1989), the selected cases in each paper were chosen because they represented a variety of different contexts and because they enabled a comparison of the findings across several cases, which strengthens the robustness of the conclusions. Because I wanted to explore cases in this thesis in which actual knowledge transfer had taken place, I selected 15 BIPs that were among the top-performing projects in terms of their contribution to profit reported by the lead firms three years after project completion. The firms conducting the projects ranged in size from small start-ups to large industrial firms and varied in industry, size, type of innovation developed, and level of R&D experience. In the FFF data set, all the firms that participated within the alliance were selected as cases, and they varied in size and R&D experience. Third, together with a research team, I have collected data from six of the FMEs, and data from one of the centers are also used in this thesis. In the selected FME, three firms were selected as cases because they were among the most involved and engaged firms in the center.

3.3.4 Unit of analysis

The unit of analysis in a study is based on the research question and the theoretical assumptions (Yin, 2009). The overall research question of this thesis explores how social integration mechanisms are developed in university-industry collaboration to foster firm innovations, where firms represent the overall unit of analysis. However, as Table 3-1 shows, the articles included in this thesis adopt different levels of analysis. Innovation projects constitute the unit of analysis in Papers 2 and 3, and they were critical entities in the collaboration because they included all the participants involved in the development of innovation through university-industry collaboration. Hence, studying innovation projects enabled me to move closer to where the actual collaboration occurred. With respect to the hermeneutics approach, the chosen levels of analysis enable me to understand more of the totality that the firms were a part of. Moreover, such a unit of analysis was useful in the multi-level analysis in which I studied both the individual and the organizational levels of social capital, as both individuals and organizations likely influence the outcomes of research alliances and innovation projects.

3.4 Research process

This section presents a discussion of the research process, beginning with my initial motivation and drive for the topic of this thesis.

3.4.1 Initial motivation

The research process for this thesis was inspired by social constructionism. According to Turnbull (2002), the research process often begins with a researcher's interest in a certain topic, which was the case when I began as a PhD student and chose a research topic. Since the end of my Masters of Science education—where my colleague Siri

Jakobsen, who is also a PhD student, and I wrote a master's thesis on energy and material exchanges in a local Industrial park, Mo Industrial Park—I have been increasingly interested in doing more research that is relevant to the industry in my local community. Subsequently, I was employed as one of the three first PhD students at Bodø Graduate School of Business, Campus Helgeland, which focuses on research with relevance to local industry. Below, I will present a short history of the industry in the Nordland region, which has highly motivated me in pursuing my PhD.

The Nordland region in which I grew up is an industry-intensive region in which industrial firms have contributed to the development of international industry, which has had ripple effects on the local community. Industry in the Nordland region is mainly represented by the process, metal and engineering industries. The process industry, for instance, is responsible for approximately 75% of all exports from the Nordland region, mainly producing ferro-alloy and aluminum products (Torstensen, 2009). The process industry has been particularly important for employment in Nordland, and it was the main reason for the population growth after the Second World War. In addition, the process industry in Nordland contributes to addressing important global environmental and climate challenges. Because the industry in Nordland mainly functions on hydroelectric power, which is 100% renewable energy, it has substantially lower emissions than similar industry in other places around the world.

Gradually, the industry has faced increasingly competitive pressure and stricter policy regulations, and the need for product and process improvements has increased. As this thesis highlights, R&D collaboration is important when firms seek to increase their innovation performance. R&D collaboration is also particularly important for the development of environmental innovations because such innovations are complex and beyond firms' core competences, requiring information and skills that are new to firms (De Marchi, 2012). Although the positive effects of R&D collaboration have been widely documented in the literature, the industry in

Nordland has shown little engagement in R&D collaboration. Because the Nordland region is heavily represented by industry, in which firms must cope with international competition to maintain and increase their market shares, I find this lack of R&D collaboration troubling. However, I am motivated to obtain knowledge on barriers to and success criteria for R&D collaboration and to further convey such knowledge to industrial firms in Nordland. In summary, my interest in pursuing a PhD was to collaborate with Nordland industry to increase its competitiveness by developing energy-saving and cost-effective innovations that aim to minimize the impact of geographic distance to potential collaborative R&D partners.

Given my motivation to obtain knowledge that would help industrial firms in my region become more R&D oriented, it was natural for me to do research on R&D collaboration programs that have succeeded in developing innovations and that would enable participation from firms in the Nordland region. I want to learn from successful collaborations to further transfer this knowledge to local industry, which has struggled to establish R&D collaborations. I therefore have a special motivation for doing my PhD that is valuable to the region in which I grew up and live. Based on the R&D needs of my local community, I selected university-industry collaboration programs as the empirical setting for this thesis.

3.4.2 Development of the thesis

Based on the initial motivation to obtain knowledge that would help industrial firms in my region become more R&D oriented (see Table 3-3), I developed research questions, and these changed several times as the thesis took shape (Turnbull, 2002). Initial interviews with potential informants within Nordland's local industry were conducted, where research questions were "tested" for practical reasons (inductive) using networks of contacts (Turnbull, 2002). The early assumption that many industrial firms in my local community struggle to collaborate with PROs was confirmed. I thus decided to investigate mechanisms behind successful examples of

university-industry collaboration, and I began to gain access to an appropriate empirical setting (Turnbull, 2002).

Further, I was invited to participate in a research team together with Einar Rasmussen, Tommy Høyvarde Clausen and Siri Jakobsen, and we collected data on BIPs that are used in two of my articles. In addition, together with my colleague, Siri Jakobsen, with whom I share an interest in local industry in the Nordland region, I collected data for the second case of this thesis, the FFF, which were used for two of the papers in this thesis.

According to Turnbull (2002), it is not always easy gain access to an appropriate setting for conducting research, and when contacting potential informants, one must consider offers in return. When contacting the FFF alliance to gain access to relevant data, I found that they were a bit skeptical of our aim to use the alliance as a case in our research and that they were afraid that we would leak important business information. To ensure that they understood our research aim, which was to study collaborative processes rather than technical issues that they did not want to publish, we were able to present the purpose of researching the alliance and the expected benefits for them in a board meeting. The expressed benefits were (1) an increased understanding regarding university-industry collaboration in their alliance in light of theories and comparisons with other research alliances and (2) implications regarding how they could achieve better collaboration and improve innovation outcomes.

After almost a year home with my newborn daughter, I continued writing Papers 1 and 2 based on the theoretical concept of proximity dimensions. After writing these papers, I found that social relations hold particular importance for university-industry collaborations, which motivated me to conduct further study on social capital. Subsequently, I began analyzing the data for and writing Paper 3. Based on the first two data sets, I discovered the value of collaborating with competitors in R&D activities (FFF) and the value of having firm leading common R&D projects with PROs (BIPs). This lead to me to collect data on the FMEs because I wanted to

investigate a research alliance that—in contrast to the previous types of collaboration—consisted of firm partners from different parts of a value chain and that was run by a PRO. The FME data were collected together with a PhD student at University of Nordland, Thomas Lauvås, in 2013, and were included in Paper 4, in which I compared the data with the FFF data set. Based on our lessons from interacting with the FFF alliance, we clearly expressed the purpose and mutual benefits of conducting the research to the center manager, who allowed us to research the FME research alliance. I transitioned between reading prior literature, engaging in the field, and analyzing the data during the entire process, beginning with general ideas and moving toward specific concepts as the research question of each of the papers developed.

Following the hermeneutic approach, I acknowledge that my doctorate research has developed as a process starting with an overall research question, which has changed over time through an acquired understanding of university-industry collaboration. Moving back and forth between my papers by interpreting and trying to understand and accumulate new knowledge, I have acquired greater knowledge about the totality (university-industry collaboration) through an increased understanding of different parts (papers). In addition, by developing an understanding of the parts (different types of university-industry collaboration), I have acquired a greater understanding of the totality. Hence, my research process has unfolded as a hermeneutic circle.

Table 3-3 Development of the thesis

Activities	Time				
	2010	2011	2012	2013	2014
Developed initial RQ and proposal	X				
Initial interviews within local industrial firms	X				
Read prior studies	X	X	X	X	X
Collected data set 1 (15 BIPs)	X				
Initial interviews with firms within the second case (FFF research alliance)		X			
Collected data set 2 (FFF research alliance)		X			X
Collected data set 3 (FME research alliance)				X	X
Analyzed data from the second case and wrote Paper 1			X	X	X
Analyzed data from the first case and wrote Paper 2			X	X	X
Analyzed data from the first case and wrote Paper 3				X	X
Analyzed data from the second and fourth case and wrote Paper 4					X
Developed the umbrella part of the thesis					X

3.5 Data collection

The methods of social constructionist research are often qualitative and involve gathering data through interviews and observations to understand individuals' thoughts and experiences (Easterby-Smith et al., 2008, Turnbull, 2002). In addition to archives, interviews and observations are also the most important data sources for case studies (Yin, 2009). Through *conversations* with people involved in university-industry collaborations, I have tried to *understand* the *meanings* behind the creation of social integration mechanisms and have tried to understand the "reality" of the collaborations based on the subjective thoughts and experiences among the participants, which a case study is particularly suitable for exploring (Yin, 2009).

In-depth interviews were conducted with informants for all three data sets. To be able to triangulate between different data sources, secondary sources such as initial project descriptions, mid-term evaluations and final reports were also collected. Mason (2005) presents a variety of reasons for using in-depth interviews as a research method. Consistent with the reasons presented by Mason, the ontological perspective of this thesis is to employ a loose approach to understand the subjective thoughts and experiences of the informants. The epistemological basis for using

qualitative interviews is that I (as the researcher) want to talk to, interact with, and actively listen to the informants and ask them questions about their experiences related to the collaboration to ascertain the informants' knowledge, understandings, experiences and interactions related to how social integration mechanisms are developed in university-industry collaborations.

The interviews are conversational rather than structured interview guides in a case study approach (Yin, 2009). Longitudinal data collection is often used in the social constructionist approach (Lindgren and Packendorff, 2009), and such a method was used with the FFF and the FME data sets. Table 3-4 shows the data collection process in this thesis, which includes triangulation of different data sources (Yin, 2009).

The data collection process was relatively similar for each of the data sets, but there are some differences. First, the BIP data set includes archival material, such as the initial project description, the final report, and the assessment of the R&D program, as well as survey responses from the firms at the start of the project, at the end of the project, and three years after the end of the project. Because all projects in this data set were part of a public support program, similar information was obtained in all the cases. In addition, relevant written documentation was collected from press articles, web pages and other sources. Furthermore, on average, three key persons were interviewed in each project, including representatives from both the firms and the PROs. These interviews provided a thorough understanding of how the innovation process unfolded in each case, including interactions between the project and firm levels. Multiple informants were used to increase the validity of the retrospective accounts (Miller et al., 1997). In total, 32 face-to-face interviews and eight telephone interviews were conducted.

Second, the data collection process for the FFF data set began with observations at a seminar arranged by the FFF alliance, during which each project was presented and discussed. The aim of these observations was to learn about the projects, to become acquainted with the participants and to begin to observe their

cooperative efforts. This data set includes presentations by all the firms as well as their annual reports. In total, 32 longitudinal interviews were conducted, and all the interviewees were participants in one or several of the four research projects being conducted by the FFF alliance.

Third, the FME data set includes annual reports and midterm evaluations of the alliance. The FME interviews were collected as a part of a larger project in which a research team collected data from six FME alliances representing firms, PROs and interest organizations. For this thesis, data from one of the FME alliances are used, and 27 longitudinal interviews were conducted.

Table 3-4 Data collection

Data set	Secondary sources	Informants interviewed			
		2010	2011	2013-2014	Total
BIPs	Project description Final reports Survey responses from the firms	15 project managers 12 firm researchers 13 PROs			40
FFF alliance	Firm presentations Annual reports Press articles		14 firms 4 PROs 1 industry federation	8 firms 5 firms	32
FME alliance	Annual reports Evaluation reports		4 firms 8 PROs 2 interest organizations	4 firms 8 PROs 1 interest organization	27
		40	33	26	99

3.5.1 Written documents

Written documents are relevant to many case studies, and they were collected in this thesis for several reasons (Yin, 2014). Project descriptions, final reports and survey responses from firms in the BIP data set were directly used in the process of analyzing the data, as such information came directly from the informants. Comparisons between project descriptions and final reports indicated collaborative changes in

university-industry collaborations over time. Second, secondary sources in the FFF data set were used to verify information such as titles and names and to understand the background of the cases before the interviews were conducted (Yin, 2014). Third, annual reports and evaluation reports were used in the FME data set to verify information such as titles and names and to identify informants (Yin, 2009). These reports were also used to understand the background of the cases before the interviews were conducted and to design effective questions for the interviews (Yin, 2009), such as “According to the evaluation report, the alliance has experienced challenges regarding communication. Do you agree with that statement?”

Apart from in the BIP data set, the collected written documents were generally not used directly in the analysis; instead, they were mainly used as information sources for further investigation (Yin, 2014).

3.5.2 The interview process

Interviews are effective for enriching empirical data (Eisenhardt and Graebner, 2007) and constitute the main source of data for this thesis. Social constructivist researchers aim to understand how/why issues by examining stories from people involved in processes; thus, the methods of analysis adopted are often narrative (Hjorth, 2007). In the social constructionism approach, theory building is derived from situational experiences, and findings are often presented in a narrative approach collected through stories and critical incidents (Turnbull, 2002). To obtain an understanding of the story and critical incidents affecting the development of social integration mechanisms in university-industry collaborations, a narrative interview approach was used for the two first data sets (i.e., the interviews for the BIP data set and the first round of interviews for the FFF data set). A narrative interview approach is a valuable means of gaining deeper insight into organizations’ underlying structures (Pentland, 1999).

Following a narrative interview approach, the interviewers encouraged the informants to provide chronological accounts regarding the gradual development of the collaboration in which they took part and to describe their involvement in the collaboration from its beginning to the present, with minimal interruption by the interviewers. The informants were encouraged to be open and to speak freely with minimal interruption (Polkinhorne, 1988) to increase the likelihood that they would provide information that may not have been captured by static questions. To gain detailed information on the critical events and actors involved throughout the process, open-ended follow-up questions were used, such as, “Why did you do that?” “Who was involved in this event?” “When did this happen?” To avoid bias, we did not explicitly use theoretical concepts in the interview setting. The final reason for using a narrative interview approach was to minimize any influence from personal factors or the relevant theory on the data collection process (Czarniawska, 1998).

A semi-structured interview guide was used in interviews for the BIP data set and in the first round of interviews for the FFF data set if the dialogue was restrained. As the focus of the thesis narrowed, a more structured interview guide was used in the second round of interviews for the FFF data set and in the interviews for the FME data set for questions regarding the thesis’s theoretical focus and aim. Although a more structured guide was used here, the narrative interview approach was kept in mind to increase the likelihood that the informants would provide information that may not have been captured using static questions.

All the interviews were recorded and transcribed as part of the data analysis process.

3.6 Data analysis

Data collection and analysis have been an ongoing process embedded in my work during the research process (Eisenhardt, 1989). In line with social constructionism,

the interviews were coded by looking at the informants' experiences related to university-industry collaboration. First, to systematically analyze the new knowledge, the interviews were transcribed in their entirety (Yin, 2009). Next, the interview transcripts were read and reread as the data were collected (Yin, 2009) to gain familiarity with each case and to develop the capability to identify general patterns across cases (Eisenhardt, 1989).

To avoid false conclusions based on bias and to enhance the fit between theory building and data, I categorized the data based on theoretical dimensions, seeking to identify similarities and differences across the cases and the literature (Eisenhardt, 1989). For all four papers, the data analysis was based on cross-case comparisons, and the aim was to identify cross-case patterns (Yin, 2009) related to the collaboration and to identify changes over time.

In the process of identifying cross-case patterns, I followed an analytical strategy (Yin, 2014) in which I started "playing" with the data by looking for theoretical perspectives that emerged from within the data. Using both inductive and deductive approaches, I then went back and forth between the data and theories to find useful concepts to build theory on university-industry collaboration. As I became more familiar with both the data and relevant theories, information from the data was put *into different arrays*. Further, a *matrix of theoretical categories* and subcategories was developed and used to codify the data. The information from the data was then set in *data displays* in the form of tables. The *frequency of different events* was tabulated, particularly for the longitudinal data sets, to identify changes over time related to the use of social integration mechanisms in university-industry collaboration. The data were tabulated in *chronological order* to arrive at an organized overview of the data. Finally, to facilitate analytical generalization, the findings from each case in the matrix were compared using pattern matching. Based on findings from the case study, I searched for similarities and differences across the cases and the chosen theories to build theory. Finally, propositions were developed

in all the papers through analytical generalization guided by relevant theory (Yin, 2009). The process of building theory in this thesis was not linear but instead involved movement back and forth between the data and theory because of the increased understanding of the use of social integration mechanisms in university-industry collaborations that was gained during the process.

3.7 Evaluation of the data material

Evaluating the data material is important in both quantitative and qualitative studies (Eisenhardt, 1989). Methodological consciousness, which is used to ensure quality in qualitative research, refers to the openness of data reporting and the extent to which a researcher highlights the most relevant information from the data material such that readers understand the basis of the conclusions derived therefrom (Silverman, 2005). Various methods, including tests of validity and reliability, can be used to ensure methodological awareness in qualitative research.

The validity of a study refers to the extent to which the conclusions derived accurately correspond to a social phenomenon (Silverman, 2005). Social constructionist research aims to understand reality (Turnbull, 2002), which this thesis has aimed to do by presenting valid data. To ensure that this thesis represents the *reality of* the social phenomenon known as university-industry collaboration, I have reflected on my cases during the research process and have asked myself questions related to the suitability of the cases for illustrating the theoretical basis employed, such as, "Does my study answer what it is supposed to answer?" "Do I use relevant sources and cases to build theory on university-industry collaboration?" "Is the chosen methodology and literature suitable for answering my research questions?" I have also invited other scholars to discuss these questions with me. The awareness of validity during the research process led to either new decisions or a stronger commitment to continue in the chosen path. External validity concerns whether and to what extent research results can be transferred to contexts other than the context

that is the object of study (Johnson and Duberly, 2000). To increase the external validity of the study, I have chosen contexts and theories that on some level likely say something about not only the context chosen for this thesis but other contexts as well. Although my findings cannot be directly generalized to a large population, they likely shed new light on other types of collaboration and on the manner in which individuals and firms manage useful collaborations.

The reliability of the data relates to the data process, the data used, and the collection and processing methods employed, and high reliability results in a greater ability to answer research questions. (Halvorsen, 1989). To enhance reliability, a researcher can provide a detailed description of the study object and a detailed account of the methods used for collecting and processing the data (Johannessen et al., 2005). To meet the criteria of reliability, this thesis provides a detailed description of its cases and methods and the reasons why such cases and methods were chosen.

Moreover, Alvesson and Sköldbberg (2009) indicate that research should be rich to enhance the quality of qualitative research, which this thesis has aimed to achieve by adding rich interpretations regarding university-industry collaboration based on data and theories.

3.8 Critical reflections on the methodology

At the end, I asked myself whether the chosen methodology was suitable for my research and conclusions. As Silverman (2005) notes, there is no right or wrong approach—only approaches that are more or less appropriate for a specific setting. To answer questions regarding how social integration mechanisms are developed in university-industry collaboration to foster firm innovations, the methodology is reasonably chosen to arrive at an in-depth understanding of the interaction process between collaborating parties.

The social constructionist approach has enabled me to arrive at an in-depth understanding of individuals' understanding and experiences related to university-industry collaboration. By conceptualizing collaborations as social constructions of individuals who are given meaning by the actors, I have been able to understand how innovations are created through relations and enhanced by people's experiences rather than how innovations explain behavior. Social constructionism has helped me as a researcher to understand what occurs within different types of collaborations and to build theory on university-industry collaboration based on the underlying mechanisms of what makes such collaborations successful, which has been called for by several authors. What I might have lost by neglecting positivism is the possibility to generalize the findings, but such an approach would have prevented me from gaining an in-depth understanding of the subject matter and would have been more suitable if the intention was to look for causality.

Further, by adopting elements from the hermeneutic approach, I have been able to consider my pre-understanding in interpreting and understanding people according to the contexts and situations in which they are situated, which has likely contributed to trustworthy theory building on university-industry collaboration. I acknowledge that both approaches, namely, social constructionism and hermeneutics, are suitable for studying the process of university-industry collaboration. By applying both approaches, I likely obtained information about my informants' experiences and meanings that I might not otherwise have obtained, and I hope that I have been able to become conscious of my pre-understanding in my meetings with the respondents and in the work in the analysis.

Other research designs, such as quantitative approaches, might have been valuable to enhance the direct generalization of the findings based on a larger sample and to enhance my ability to look for correlations. However, using a qualitative case study has likely provided this thesis with rich in-depth information on how social integration mechanisms are developed in university-industry collaboration and has

likely added valuable insights to the mechanisms underlying this phenomenon—insights that are transferrable to other types of collaboration. The propositions developed in each of the articles identify underlying mechanisms of university-industry collaborations, which may be valuable for future quantitative studies to build upon to gain insight into a wider population and to test the in-depth findings of this thesis.

During the process of writing this thesis, I have participated in practical activities relevant to the research process, which are discussed in the next section.

3.9 Practical activities relevant to the research process

During the research process, I have engaged in other more practical activities related to the dissemination and discussion of my research on university-industry collaboration. I find it worth reflecting on some of the activities that have particularly influenced this research process and the development of this thesis. First, I participated in a project for the development of a *“strategic industry plan for the local government of Rana”* hosted by Rana Utviklingselskap, where the group that I participated in formulated the focus and development of competences—including those related to R&D development—for the municipality of Rana. Participating in this project was particularly instructive for the research process because I learned to understand the importance of my field in a more practical sphere.

Second, together with Siri Jakobsen, I was the initiator of the Center of Industrial Business Development at the Bodø Graduate School of Business. The center focuses on research and innovation projects that are relevant to Norwegian industries, particularly those in the Nordland region, based on the following business idea: *“The Center for Industrial Business Development (SIF) will conduct relevant research and teaching and contribute to robust and competitive Norwegian industries. Key areas for the center are business development, innovation and technology”*. The

establishment of SIF has highly influenced my research process. After observing the weak R&D orientation of industrial firms in the Nordland region, we were motivated to establish a research center focusing on industrial development. Through the establishment of SIF, we have arranged meetings and other activities in which we are in close contact with industry. Engagement in SIF and contact with industry during the process of writing this thesis have been invaluable, as I have continually conveyed some of my results in dialogue with industry representatives and have been able to develop my thesis in a practical matter.

Moreover, I am a member of a resource team for the Program for Regional R&D and Innovation (VRI) in Nordland, hosted by the Science Park of Helgeland. In this group, we mobilize R&D collaboration through the VRI program and evaluate R&D applications from industrial firms in Nordland. Additionally, I am a research assistant in the *“R&D mobilization in Nordland industry”* project, which has SINTEF and Nordland Research Institute as research partners. As a concern of the county council of Nordland regarding the low R&D orientation of Nordland industry, this project aims to mobilize R&D activity in industry. Participating in this project has been valuable for the last stage of the development of this thesis.

Through these projects, I have been in dialogue with industrial firms in Nordland not only to collect data for this thesis but also to use my findings pragmatically to push the firms to become more engaged in R&D activities. Experiences related to this project are manifold. As my findings in this thesis indicate, it takes time to build valuable university-industry collaboration in which firms and research partners manage to collaborate with shared goals and commitment. As a type of *“competence mediator”*, I could easily perceive such conflicts (e.g., including potential conflicts between firms and their research partners) in dialogue with firms on the one side and potential research partners on the other side. For me, it was obvious that industry with a low R&D orientation requires time to understand the purpose and value of R&D collaborations, which challenged my very presence in

dialogue between industrial firms and their potential research partners and required substantial monitoring on my part. When contacting potential research partners, I found that I had to be clear regarding the expectations from the firms' side, and repeated contact with both the firms and their research partners to achieve collaborative connections between them was important to avoid misunderstandings. I found that the achieved research competence through university-industry collaboration was valuable in this mobilization project and that it informed the dialogue, which confirmed the practical value of the academic work in this thesis. Additionally, I found that as a researcher, I cannot just walk into a setting like this, talk about my theories, and then disappear. I really must keep in touch with the firms because they formed expectations when they first entered the dialogue that I must accommodate in the best way.

In summary, the practical activities highlighted in this section have been valuable to the research process. First, initial contacts with industry influenced the research question addressed in this thesis. Then, ongoing contact with the industry and other relevant actors related to R&D ensured the practical relevance of the thesis during the research process. Finally, participating in R&D mobilization projects allowed me to use the findings of this thesis and, in turn, gave me valuable insight into the implications of my findings. I now turn to a discussion of ethical issues during the research process.

3.10 Ethical issues

Ethical issues are part of the practice of doing research. The development of this thesis involved numerous interviews and telephone and email communications with many persons, generating ethical considerations regarding who is affected by the results of this thesis. To meet the criteria for the ethical treatment of the people involved in this thesis, I have followed some of the techniques for conducting ethical research used by Christians (2005).

Informed consent - The informants involved in this research project have the right to receive information on what they are involved in, and they must voluntarily agree to participate based on sufficient information (Christians, 2005). When contacting the informants, I informed them about the aim and purpose of my research project. I also told the informants that the results would be published and that they would have the chance to approve what I had written about them before the papers were submitted for publication. Anonymity was clarified, and confidentiality statements were executed prior to data collection. Further, I sent a letter in which I explained the project and my role to the informants. The interview guide was also sent to the informants before the interviews were conducted to ensure that they were willing to provide information on the topics.

Deception - To avoid deception, I had to provide the informants with sufficient, accurate information about my research (Christians, 2005). I was honest with the informants about how their data would be used in the future. No political or any other external pressure has influenced this study, which I expressed to the informants to assuage concerns that the research had a deceptive purpose.

Privacy and confidentiality - To avoid unwanted exposure of the informants, I have been aware of protecting their privacy and confidentiality (Christians, 2005). As noted above, the FFF alliance wanted to anonymize the alliance name, industry type and the firms, which we took into consideration. We also used confidentiality assignments for all the involved informants. The two papers on this alliance contain data that is therefore completely anonymous. However, after the papers were written, they were sent for a second round of review in a FFF board meeting with the aim of making the alliance visible in this thesis, in further research and in discussions using the alliance as an example at industry and academic conferences and lectures. After discussing privacy and confidentiality concerns in the board meeting, the FFF alliance agreed to make the alliance visible in my research because the papers were interesting and valuable to them. The alliance name is therefore visible in this thesis,

but the anonymity of the firms and individuals has been maintained. For the BIPs and FME alliance, it was agreed that the type of research program would be visible in the research but that project and alliance names, as well as the names of firms and individuals, would remain anonymous.

Accuracy - During the data collection process, I have aimed at ensuring the accuracy of the data (Christians, 2005). By recording and transcribing the interviews, I avoided potential misunderstandings and ensured the data's accuracy. Prior to the interviews, the informants were notified that the interviews would be recorded.

The ethical principle that is central to the hermeneutic paradigm, the principle of charity, has also been considered to enhance the ethical performance during the research process.

3.10.1 Principle of charity

The final ethical criterion I have considered in this thesis is the principle of charity—a central principle in the hermeneutic paradigm concerning how researchers should interpret data and understand the point of view of others without engaging in subjective evaluation.

Through methods such as participant observation and in-depth interviews, researchers relate to observable actions, verbal statements and written texts, which can be difficult for researchers to understand (Gilje and Grimen, 2004). To understand a person's actions and statements, we must start by assuming that he or she is a reasonable person. Only in cases in which the person's actions and statements are entirely impossible to rationalize can the conclusion that the person is unreasonable be reached. This proposition means that researchers should interpret people's actions and statements charitably. If a person acts or says something that we do not understand, we should always assume that it is in some way reasonable, even if it is difficult to understand. The principle of charity ensures respect for other people and their understandings. By adopting this ethical principle, I have allowed the people

with whom I have spoken to speak with expressions that I actually do not understand, and I have thus been forced to show intellectual openness. We should be aware that there may be something wrong with our interpretation and that others may make sense, even if it is difficult to understand them (Gilje and Grimen, 2004). Through this principle, a researcher can aim to understand and sympathize with other people's thoughts and meanings and to simultaneously exclude his/her own understanding. Thus, other people's thoughts and meanings are assumed to be valid, even if the researcher's own immediate reaction is to disagree. This contributes to increased understanding and acceptance of one another.

With the principle of charity in mind, I have aimed to respect other people and their understanding and to interpret information charitably, and it has likely contributed to providing me with an understanding of my informants' actions, statements and meanings in both my conversations with them and my analysis. I have tried to familiarize myself with the informants' point of view and have reflected on their statements in situations in which I have disagreed with them.

4. Summary of the research papers

4.1 Introduction

This chapter summarizes the key contribution of the four papers included in this thesis. All four papers use empirical data from qualitative cases related to how social integration mechanisms are developed in university-industry collaborations to foster firm innovations. Each of the papers focuses on different types of university-industry collaboration and builds on insights from different theoretical approaches. Table 4-1 presents an overview of the research papers, including their research questions, theoretical concepts, level of analysis, focus and publication status.

Table 4-1 Papers included in the thesis

Paper	Title	Author(s)	Research question	Theoretical approaches	Focus	Level of analysis	Publication status
1	The role of proximity dimensions in increasing firms' absorptive capacity in a competition alliance: a longitudinal case study	Steinmo. M. Jakobsen. S.	How does a competition alliance facilitate increased absorptive capacity through proximity dimensions?	Coopetition Absorptive capacity Proximity dimensions: social, cognitive, geographical, technological, institutional, cultural	This study builds theory on how competing firms collaborate in a competition alliance on basic research and research on environmental issues for innovation development	Firm level	Presented at the DRUID summer conference in Barcelona (2013) and the RENT XXV conference in Bodø (2011) Revised and resubmitted to the Journal of Business Research (2013), rejected (2014) In review for a special issue on cooperation and innovation at the Int. Journal of Technological Management.
2	How firms collaborate with public research organizations: the evolution of proximity dimensions in successful innovation projects	Steinmo. M. Rasmussen. E.	How do different dimensions of proximity facilitate successful collaborations between firms and PROs, and how do these dimensions evolve over time?	Proximity dimensions: Geographical, cognitive, organizational, social	This study builds theory on how firms can develop and sustain collaborations with PROs when developing innovations in common R&D projects	Project level	Presented at the DRUID summer conference in Barcelona (2013) Revised and resubmitted in a second round with minor revision to the Journal of Business Research (2014)
3	The interplay and evolution of the dimensions of social capital in open innovation	Steinmo. M. Rasmussen. E.	How do different social integration mechanisms facilitate successful external collaboration for innovation?	Absorptive capacity Social capital: Structural, relational and cognitive	This paper builds theory on the use of social capital dimensions in successful external collaboration for innovation.	Project level	Presented at the Babson College Entrepreneurship Research Conference in Syracuse (2011) and the Academy of Management Conference in Philadelphia, USA (2014) In review at the Journal of Management Studies
4	Collaboration for Innovation: A Longitudinal Case Study on How Social Capital Mitigates Collaboration Challenges in University-Industry Research Alliances	Steinmo. M.	How can firms develop cognitive and relational social capital from PROs to mitigate tensions and to build fruitful collaboration in research alliances over time?	Social capital: Relational and cognitive	This paper builds theory on how firms and PROs manage fruitful collaborations in which tensions are mitigated and in which knowledge is enhanced in research alliances relying on two dimensions of social capital: cognitive and relational social capital.	Multi-level: Individual, organizational and alliance	Presented at the DRUID summer conference in Barcelona (2014) In review at Industry and Innovation

4.2 Research Paper 1: The role of proximity dimensions in increasing firms' absorptive capacity in a coopetition alliance: a longitudinal case study

4.2.1 Introduction and research question

This study explores how competing firms collaborate in coopetition alliances to develop environmental innovations, which are perceived as common challenges that lie far from the customer and that must be collectively addressed by an industry. In this paper, we explain how firms' absorptive capacity can be increased in a coopetition alliance involving different types of proximity as important preconditions for knowledge transfer (Gertler, 1995). The paper addresses the following research question: *How does a coopetition alliance facilitate increased absorptive capacity through proximity dimensions?*

4.2.2 Theory

The fundamental motive behind cooperation with competitors is that success in today's markets often requires firms to pursue both competitive and cooperative strategies simultaneously (Lado et al., 1997). Coopetition is relevant when competitors face a common challenge, such as when firms within the same industry try to adapt their production to new environmental regulations or when they must build more industry knowledge through basic research. The rationale behind most coopetition alliances is the expectation of reaping benefits in the form of increased knowledge and value creation, particularly under conditions with high market uncertainty. When firms share risks and costs with collaborators who possess both similar and complementary resources, the outcome can be an increased relationship portfolio and increased relative absorptive capacity (Ritala, 2012). Our study concentrates on absorptive capacity as one of the most important outcomes of coopetition. A key feature of the absorptive capacity perspective is that similarities

between partners positively affect the collaborative performance (Luo and Deng, 2009). In this paper, proximity dimensions are used to address how firms can increase their absorptive capacity in a coopetition alliance. Cooperative partners require a certain level of similar technological knowledge to be able to learn and innovate together. Cognitive proximity facilitates common understanding and effective communication, whereas social proximity enhances trust through social relationships. Being located in geographical proximity positively influences collaboration through face-to-face interactions (Boschma, 2005). In a coopetition alliance, these various types of proximity can be leveraged by the cooperative partners to increase the firms' absorptive capacity and to thereby build the industry's overall knowledge.

4.2.3 Method

The research question is examined by using longitudinal data collected from a coopetition alliance in the Norwegian ferro-alloy industry. This industry faces many environmental challenges because it is one of the most polluting industries in Norway. The alliance consists of all firms within the ferro-alloy industry in Norway, and it conducts joint research projects on products and processes. The alliance cooperates with external R&D partners (mainly universities and public research organizations), which are included in most of its projects.

4.2.4 Key findings and contribution to the thesis

This paper contributes to this thesis by exploring how firms can achieve increased absorptive capacity through proximity dimensions by participating in a coopetition alliance, thus addressing research question 1: *“How does a coopetition alliance facilitate increased absorptive capacity through proximity dimensions?”* By studying five firms in a coopetition alliance over a three-year period, we extend the literature by explaining how some firms' absorptive capacities increase in coopetition alliances.

Our in-depth qualitative study considers firms' absorptive capacity longitudinally and examines how participation in a coopetition alliance influences firms' absorptive capacity through proximity dimensions over time. We propose that social proximity reduces opportunism in a coopetition alliance by building trust and openness among the participants. These strong social ties are a precondition for obtaining a shared understanding of common technological challenges. Moreover, we propose that firms in a coopetition alliance build cognitive and technological proximity over time. We further argue that the need for geographical proximity is reduced through a coopetition alliance because such an alliance enhances social, cognitive and technological proximity. In summary, we find that social proximity is the strongest driver for increased absorptive capacity because it is necessary for increasing cognitive and technological proximities. We further find that these proximities are crucial for increasing firms' absorptive capacities in a coopetition alliance.

4.3 Research Paper 2: How firms collaborate with public research organizations: the evolution of proximity dimensions in successful innovation projects

4.3.1 Introduction and research question

In this paper, we examine how firms can develop and sustain collaborations with universities and public research organizations (PROs) when developing innovations. Although PROs are a potentially valuable source of new knowledge, it is challenging for firms to absorb knowledge from PROs (Cohen and Levinthal, 1990), as evidenced by the many unsuccessful attempts at knowledge transfer between universities and firms (Santoro and Bierly, 2006). This difficulty often arises due to a lack of trust and understanding in communications and interactions between firms and academics. This study builds on the proximity concept, which is thought to play an important role in explaining successful inter-organizational collaborations (Knoben and Oerlemans,

2006)”. The paper addresses the following research question: *How do different dimensions of proximity facilitate successful collaborations between firms and PROs, and how do these dimensions evolve over time?*

4.3.2 Theory

The proximity literature has developed a fine-grained framework for understanding different aspects of inter-organizational collaboration (Knoben and Oerlemans, 2006, Boschma, 2005), in which different types of proximity are suggested to facilitate successful inter-organizational collaboration (Knoben and Oerlemans, 2006). Our focus is consistent with that of Broekel and Boschma (2012), who examine the role of geographical, cognitive, social, and organizational proximity in innovation performance. Geographical proximity refers to territorial or spatial proximity (Broekel and Boschma, 2012) and promotes knowledge transfer and innovation by facilitating face-to-face interactions among collaborative partners (Knoben and Oerlemans, 2006). Cognitive proximity refers to similarities in the way that actors perceive, interpret, understand and evaluate the world (Nooteboom et al., 2007). Organizational proximity refers to shared relations within or between organizations and is advantageous to innovation networks (Boschma, 2005). Social proximity refers to actors that belong to the same space of relations (Knoben and Oerlemans, 2006).

In this paper, we distinguish between science-based and engineering-based firms (Autio, 1997) and explore the combinations of proximities that are used by these two types of firms to successfully collaborate with PROs over time.

4.3.3 Method

The results are based on a qualitative case study drawn from a public support scheme that assists high-potential, user-driven innovation projects in Norwegian industry (the Research Council of Norway’s BIP program). We selected 15 user-driven innovation

projects from a sample of 709 projects that received public support during the 1996–2005 period. Each project was managed by a lead firm and included PROs and occasionally other firms as partners. The 15 projects were among the top-performing projects in terms of their contribution to profit reported by the firms three years after project completion.

4.3.4 Key findings and contribution to the thesis

This study builds theory on proximity dimensions in university-industry collaboration and addresses research question 2 of this thesis: *“How do different social integration mechanisms contribute to successful innovation projects in collaborations between firms and PROs?”* This paper shows that the evolution and interplay of proximity dimensions over time plays a key role in successful university-industry collaboration and that engineering-based and science-based firms rely on different combinations of proximities. Engineering-based firms rely on prior contacts and geographical proximity when establishing collaborations with PROs, whereas science-based firms tend to base their first contacts on cognitive proximity to establish R&D projects with geographically distant PROs. In addition to relevance, similar organizational structures (organizational proximity), shared understanding and similar technological knowledge bases (cognitive proximity) with PRO partners are important factors for science-based firms when establishing collaboration projects.

Moreover, the main contributions of our study respond to calls for a better understanding of the evolution of proximities over time and the interplay among them (Balland et al., 2014). First, engineering-based firms build cognitive proximity over time by collaborating with familiar and geographically close PROs and depend on social proximity to collaborate successfully over time. Science-based firms, by contrast, depend mostly on cognitive proximity and to some extent on organizational proximity, and they benefit from having similar R&D structures to PROs to collaborate

successfully over time. Further, science-based firms use organizational and cognitive proximity to build social proximity with unfamiliar partners over time.

Moreover, our study of innovation projects contributes to the literature by providing a multi-level analysis showing that the type of proximity that is understood to be important depends on the level of analysis that is adopted. For instance, social proximity is a key enabler of collaboration at the individual level, whereas cognitive proximity appears to be more important in maintaining long-term collaborative relationships at the organizational level. This finding indicates that engineering-based firms can develop their abilities to collaborate with PROs by collaborating with socially and geographically proximate partners. Active engagement with such initial partners can increase firms' cognitive proximity to other PROs. Hence, firms can leverage socially and geographically proximate relationships to achieve closer cognitive and organizational proximity to PROs.

4.4 Research Paper 3: The interplay and evolution of the dimensions of social capital in open innovation

4.4.1 Introduction and research question

In this paper, we explore how social capital is used and developed in collaboration projects between firms and public research organizations (PROs) to generate new innovations. It is widely accepted that social processes exert strong influences on organizational behavior and effectiveness (Granovetter, 1985). Zahra and George (2002) suggest that firms' with similar levels of potential absorptive capacity may differ in their level of realized absorptive capacity depending on their use of social integration mechanisms. Hence, different dimensions of social capital, such as structural, cognitive, and relational social capital, may be crucial for firms to be able to create and transfer knowledge in university-industry collaboration (Inkpen and Tsang, 2005, Nahapiet and Ghoshal, 1998). It has been suggested that social capital is

important for open innovation because it helps firms identify and forge effective relationships with relevant partners (Tether and Tajar, 2008). Nonetheless, the specific mechanisms behind these relationships remain unclear. Hence, we pose the following research question: *How do different social integration mechanisms facilitate successful external collaboration for innovation?*

4.4.2 Theory

The literature highlights the importance of collaborating with PROs in the development of innovations, and firms collaborating with PROs are much more likely to develop innovations (Howells et al., 2012). In this paper, we build theory regarding how firms can achieve successful university-industry collaboration by adopting the social capital concept (Inkpen and Tsang, 2005, Nahapiet and Ghoshal, 1998).

Structural social capital describes advantages related to an actors' network of contacts. It relates to the linkages between people and organizational units and can be conceived of as an overall pattern of connections among actors (Burt, 1992). Cognitive social capital refers to shared interpretations and systems of meanings (Cicourel, 1974), common language and codes (Monteverde, 1995) and shared narratives (Orr, 1990) among parties. When organizations have shared visions and systems, it is easier for them to learn from one another (Hult et al., 2004). Relational social capital focuses on relational closeness and trust and refers to "[t]hose assets created and leveraged through relationships" (Nahapiet and Ghoshal, 1998). It describes personal relationships formed through prior contacts (Granovetter, 1992) and concerns mutual respect and friendship, expectations, and reputations (Adler and Kwon, 2002). All three dimensions of social capital are found to be important for inter- and intra-organizational knowledge transfer (Van Wijk et al., 2008).

4.4.3 Method

The results are obtained from a qualitative case study drawn from a public support scheme that assists high-potential, user-driven innovation projects in Norwegian industry (the Research Council of Norway's BIP program). We selected 15 user-driven innovation projects from a population of 709 projects that have received public support during the period from 1996 to 2005. Each project was managed by a lead firm and included PROs and occasionally other firms as partners. The 15 projects were among the top-performing projects in terms of their contribution to profit reported by the firms three years after project completion.

4.4.4 Key findings and contribution to the thesis

This study explores social capital in university-industry collaboration and addresses research question 2 of this thesis: *"How do different social integration mechanisms contribute to successful innovation projects in collaborations between firms and PROs?"* This study shows that the structural, cognitive, and relational dimensions of social capital are all important for achieving fruitful collaboration. We found that, depending on their prior experiences, firms use different paths to build the social capital required for successful collaboration. Firms with extensive prior experience in collaborating with PROs tend to rely on several and diverse connections, which they are able to access through high levels of cognitive social capital. These organizational-level properties are further strengthened over time by the development of relational social capital at the individual level. Less experienced firms rely on few and stable connections with PROs dominated by relational social capital at the individual level. However, over time, these firms may build cognitive social capital that strengthens their organizational-level connections to PROs. Hence, our findings elucidate the link between individual and firm-level aspects of social capital, a relationship which is poorly understood (Payne et al., 2011).

An notable finding is that firms with lower levels of collaboration experience, regardless of their size, are able to collaborate successfully with PROs. Despite their lower level of cognitive social capital, these firms rely on individual relations when establishing collaborations. Hence, we argue that a high level of relational social capital compensates for the lack of cognitive social capital. Firms with lower levels of R&D collaboration experience manage to build cognitive social capital through relational social capital over time, which helps them overcome communication challenges. This case study thus clearly highlights the importance of trust and relational social capital in collaborations between firms and their PRO partners. Furthermore, this study shows how firms with limited levels of cognitive social capital can build effective social relationships through relational social capital at the individual level. However, relying on few and stable connections to PROs may have some negative consequences. First, reliance on a limited number of connections may render those less experienced firms vulnerable over time. Because such a firm may have few employees who collaborate with individuals in a PRO, the entire R&D activity of the firm may be at risk if, for instance, some of the collaborative individuals quit or change work assignments. Another negative consequence may be that stable connections with particular PROs prevent firms from involving other research partners, which may add newer and more valuable knowledge to the firm than the existing collaborative partners provide.

Although reliance on relational social capital has drawbacks related to a narrower set of possible collaboration partners, this may be a cost-effective solution for smaller firms with limited resources to develop cognitive social capital with PROs. As a starting point, less experienced firms should be able to collaborate and create innovations in collaboration with PROs through relational social capital, but to maintain their innovation performance, they should strengthen their R&D focus by internalizing and broadening their R&D orientation particularly as related to strategies and management. Further, by transferring individuals' relations to an

organizational level, firms can strengthen their organizational cognitive social capital and thereby strengthen their R&D capacity.

4.5 Research Paper 4: Collaboration for Innovation: A Longitudinal Case Study on How Social Capital Mitigates Collaboration Challenges in University-Industry Research Alliances

4.5.1 Introduction and research question

Although many firms recognize the importance of collaborating with PROs in innovation development, they are often reluctant to use these external knowledge sources. Indeed, firms often find achieving effective collaboration challenging because both firms and PROs must compromise their interests in the pursuit of collaboration. Firms and PROs may have conflicting goals in terms of organizational structure, management, goals and approaches to problem solving, which makes collaboration between academic and commercial activities challenging and gives rise to tension (Ambos et al., 2008). This paper develops theory on how firms and PROs manage fruitful collaborations in which tensions are mitigated and in which knowledge and innovations are created in research alliances by developing cognitive and relational social capital. This study explores the following research question: “How can firms develop cognitive and relational social capital in their relationships with PROs to mitigate tensions and build fruitful collaborations in research alliances over time?”

4.5.2 Theory

Social capital is important for university-industry collaboration because it facilitates interaction and trust between collaborative partners (Inkpen and Tsang, 2005) as well as knowledge acquisition (Parra-Requena et al., 2013). This study adopts theory on

cognitive and relational social capital (Nahapiet and Ghoshal, 1998). A mutual lack of understanding concerning working practices and expectations has been found to be a barrier to university-industry collaboration (Bruneel et al., 2010), and building cognitive social capital may be a way to overcome this challenge. Cognitive social capital refers to shared interpretations and systems of meanings (Cicourel, 1974), common language and codes (Monteverde, 1995), and shared narratives (Orr, 1990) among parties. When organizations have shared visions and systems, it is easier for them to learn from one another (Hult et al., 2004). Relational social capital focuses on relational closeness and trust and refers to “those assets created and leveraged through relationships” (Nahapiet and Ghoshal, 1998). This term describes personal relationships formed through prior contacts (Granovetter, 1992) and concerns mutual respect and friendship, expectations and reputations (Adler and Kwon, 2002). Prior experience in collaboration has been found to reduce barriers to university-industry collaboration (Hagedoorn and Schakenraad, 1994). Petruzzelli (2011) found that the existence of previous collaborations promotes trust between academic and industrial partners, illustrating the usefulness of building personal relationships when developing technologies.

4.5.3 Method

The results build upon a qualitative case study drawn from data collected from two research alliances in Norway: The first is a well-established research alliance with the objective of pursuing environmental improvements and increasing the technological qualifications of industry employees. The second is an emerging research alliance that had the objective of conducting high-level, long-term international research to solve specific challenges in the energy industry and to identify new and innovative solutions. The studied research alliances support firms that develop innovations through long-term R&D activities in research alliances with PROs.

4.5.4 Key findings and contribution to the thesis

This study builds theory on social capital in university-industry collaboration and addresses research question 3 in this thesis: *“How can firms develop cognitive and relational social capital in their relationships with PROs to mitigate tensions and build fruitful collaborations in research alliances over time?”* This study shows that the development of cognitive and relational social capital is important for the achievement of successful collaboration between firms and PROs in research alliances in which tensions are mitigated and in which knowledge and innovations are enhanced. Moreover, the paper shows that social capital requires time to develop. The findings also make important contributions to the literature regarding the levels of analysis considered. Social capital dimensions should be regarded not as characteristics of an individual organization but as capabilities that are developed over time in relationships between individuals and organizations. Firms should address the importance of developing both cognitive and relational social capital in their relationships with PROs at an individual, organizational and alliance level to create robust collaborations and to reduce the vulnerability from having only individual social capital. Moreover, this study contributes to a better understanding of the interplay among the dimensions of social capital. Cognitive social capital leverages relational social capital because it is easier to create personal relationships between firms and PROs when they agree on the collaborative fundamentals. Conversely, relational social capital plays a role in developing cognitive social capital for firms that lack a common understanding and shared goals with collaborating PROs. These findings have important implications for firms collaborating with PROs in research alliances: at least one dimension of social capital should be developed when entering into a collaboration to realize the other dimensions. Contradicting previous findings showing that relational social capital is the strongest driver of university-industry collaboration (Van Wijk et al., 2008), this study thus observes that cognitive social capital acts as an equally strong driver of university-industry collaboration.

Moreover, developing either relational or cognitive social capital early in the collaboration is important for developing the missing social capital dimensions at the individual, organizational and alliance levels, and the development of these missing social capital dimensions is found to be essential for achieving fruitful and viable collaboration in research alliances in which the partners create knowledge and innovation.

5. Conclusions

5.1 Introduction

This chapter summarizes the main findings and contributions of this thesis on how social integration mechanisms are developed in university-industry collaboration to foster firm innovation. This chapter begins by outlining the main findings related to each research question. Then, the theoretical contributions and practical implications for firms, PROs and policy makers are discussed. Finally, the limitations and implications for further research are presented.

5.2 Key findings

This thesis explores how social integration mechanisms are developed in university-industry collaboration to foster firm innovations. By studying three research programs in which firms and PROs collaborate in innovation development, I have developed four empirical papers outlining how firms with both high levels of R&D experience and low levels of R&D experience develop social integration mechanisms (i.e., social capital and proximity dimensions) through collaboration with PROs. Differences in organizational structures and management between firms and PROs sometimes make university-industry collaboration challenging; however, the development of social capital and proximity dimensions is essential to mitigate collaborative challenges and to foster the creation of firm innovations. Building social integration mechanisms takes time, but they are highly important for the development of innovations because they promote other mechanisms that underlie successful collaboration such as personal relations, trust, common goals and understanding. Each of the four articles has generated several key findings related to each research question of this thesis. Paper 1 addresses research question one of this thesis, Papers 2 and 3 address research question two, and research question three is addressed in Paper 4. Table 5-1 briefly summarizes the key findings and main contributions of each article.

Table 5-1 Overview of the key findings and main contributions of the articles included in this thesis

Focus of the study	RQ	Research question	Key findings	Contribution
The role of proximity dimensions in increasing firms' absorptive capacity in a cooperation alliance: a longitudinal case study	1	How do proximity dimensions help firms to utilize and develop absorptive capacity in cooperation alliances?	<ol style="list-style-type: none"> 1. The risk of opportunistic behavior among the firms within a cooperation alliance is lower when the level of social proximity is high. 2. Cooperation alliances can increase the cognitive proximity among firms by facilitating communication and social interactions that address shared technological challenges. 3. Lack of cognitive proximity among firms in a cooperation alliance can be compensated for by building social proximity over time. 4. Cooperation alliances can facilitate the technological proximity of participating firms by facilitating communication and social interactions focused on shared technological challenges. 5. Cooperation alliances reduce the need for geographical proximity in building absorptive capacity because cooperation enhances social, cognitive and technological proximity. 	<p>This article contributes new longitudinal evidence to theory on how cooperation alliances facilitate increased absorptive capacity through proximity dimensions. Social, cognitive and technological proximities are crucial for increased absorptive capacity for firms within a cooperation alliance. For the firms studied, the cooperation alliance has built trust and openness among the participating firms through longstanding close relationships and collaboration. Some firms have strengthened their absorptive capacity over time. This pattern is most evident among two of the firms with an initially low absorptive capacity. These firms have increased their use of external cooperation over time and have a more proactive attitude toward change.</p>
How firms collaborate with public research organizations: the evolution of proximity dimensions in successful innovation projects	2	How do different dimensions of proximity facilitate successful collaborations between firms and PROs, and how do these dimensions evolve over time?	<ol style="list-style-type: none"> 1. Compared with science-based firms, engineering-based firms are more dependent on social and geographical proximity to establish successful innovation projects in collaboration with PROs. 2. Compared with engineering-based firms, science-based firms have higher cognitive and organizational proximity to PROs and are therefore less dependent on social proximity and geographical proximity to establish successful innovation projects in collaboration with PROs. 3. Engineering-based firms that actively engage in R&D collaboration with socially and geographically proximate PROs are more likely to subsequently develop cognitive proximity to other PROs. 4. Science-based firms that actively engage in R&D collaboration with organizationally and cognitively proximate PROs are more likely to subsequently develop social proximity to these PROs over time. 	<p>This article offers novel insights into the mechanisms underlying successful collaborations in innovation projects. We find that, depending on a firm's characteristics, different proximity dimensions are important to establish new collaborations. Whereas engineering-based firms tend to rely on geographical and social proximity to PROs, science-based firms rely more heavily on cognitive and organizational proximity.</p> <p>Over time, engineering-based firms build cognitive proximity by collaborating with familiar and geographically close PROs, and they are dependent on social proximity to sustain successful collaboration over time. By contrast, science-based firms depend primarily on cognitive proximity and to some extent on organizational proximity, and they benefit from having R&D structures that are similar to PROs to collaborate successfully over time.</p>

<p>The interplay and evolution of the dimensions of social capital in open innovation</p>	<p>2</p>	<p>How do different social integration mechanisms facilitate successful external collaboration for innovation?</p>	<ol style="list-style-type: none"> 1. Firms with higher levels of prior experience with PRO collaboration are more likely to base their PRO collaborations on several less stable social relationships compared with firms having lower levels of prior experience with PRO collaboration. 2. Firms with higher levels of prior experience with PRO collaboration are more likely to base their PRO collaborations on organizational social relationships rather than individual social relationships compared with firms with lower levels of prior experience with PRO collaboration. 3. Firms with higher levels of prior experience with PRO collaboration are more likely to base their PRO collaborations on cognitive social capital at the organizational level compared with firms with lower levels of prior experience with PRO collaboration. 4. Firms with lower levels of prior experience with PRO collaboration are more likely to base their PRO collaborations on relational social capital at the individual level compared with firms with higher levels of prior experience with PRO collaboration. 5. Firms with higher levels of prior experience with PRO collaboration are more likely to initially base their PRO collaborations on organizational-level social capital that is leveraged into both organizational-level and individual-level social capital over time. 6. Firms with lower levels of prior experience with PRO collaboration are more likely to initially base their PRO collaborations on individual-level social capital that is leveraged into both organizational-level and individual-level social capital over time. 	<p>This article contributes to the open innovation and absorptive capacity literature by disentangling the social integration mechanisms by which firms can build and realize their absorptive capacity. We found that, depending on their prior experience, firms use different paths to build the social capital required for successful collaboration. Firms with a lower level of cognitive social capital at the organizational level relied on individual relations when establishing collaborations. Hence, we argue that a high level of relational social capital compensates for the lack of cognitive social capital.</p>
<p>How Social Capital Mitigates Collaboration Challenges in University-Industry Research Alliances: A Longitudinal Case Study</p>	<p>3</p>	<p>How can firms develop cognitive and relational social capital in their relationships with PROs to mitigate tensions and to build fruitful collaboration in research alliances over time?</p>	<ol style="list-style-type: none"> 1. A higher level of involvement in a research alliance increases firms' cognitive social capital toward PROs. 2. Cognitive social capital must be present at an individual, organizational and alliance level to achieve fruitful collaboration between firms and PROs in research alliances over time. 3. Firms with a higher level of initial relational social capital are better able to influence the objectives of projects in research alliances and to reduce collaborative challenges compared with firms with a lower level of relational social capital. 4. A higher level of involvement in a research alliance increases firms' relational social capital in their collaboration with PROs. 5. Relational social capital must be present at an individual, organizational and alliance level to achieve fruitful collaboration between firms and PROs in research alliances over time. 	<p>By longitudinally studying six firms within two contrasting research alliances, Research Paper 4 contributes to theory on how the development of cognitive and relational social capital can mitigate collaborative challenges, foster fruitful collaboration between firms and PROs in research alliances over time and lead to the development of innovations. The findings demonstrate that the existence of cognitive and relational social capital at three levels, namely, the individual, organizational and alliance level, constitutes a crucial determinant of the ability of fruitful collaboration between firms and PROs in research alliances to release firms' innovation potential. The development of the social capital dimensions is also found to be highly dependent on time. Moreover, the presence of at least one of the dimensions of social capital appears to be necessary when firms enter a research alliance for the first time because cognitive and relational social capital are found to be mutually reinforced over time.</p>

5.3 Theoretical contributions to university-industry collaboration

The effects of university-industry collaborations on innovation performance are well documented (e.g. Dahlander and Gann, 2010); however, the mechanisms underlying successful university-industry collaboration are poorly understood (Perkmann and Walsh, 2007). Moreover, calls have been made for studies of the success factors involved in university-industry collaboration (Giuliani and Arza, 2009) and the micro-level mechanisms involved in university-industry collaboration, such as individuals, processes, structures, and their interactions (Felin et al., 2012). This thesis responds to these calls for research by contributing to theory on *how* social integration mechanisms are developed in university-industry collaboration to foster firm innovations. Further, this thesis adopts the theoretical concepts of social capital and proximity dimensions, which are fine-grained frameworks of understanding the underlying mechanisms and social processes involved in university-industry collaboration. Zahra and George (2002) explain social capital as a social integration mechanism whereby firms can realize their potential absorptive capacity. In addition to social capital, this thesis includes the concept of proximity to offer a deeper understanding of social integration mechanisms and the development of these mechanisms in university-industry collaboration.

Confirming the previous literature that is identified in the literature review above, the results show that similar knowledge bases between firms and research partners (Petruzzelli, 2011), trust (Bruneel et al., 2010), prior contacts (Bruneel et al., 2010, Lhuillery and Pfister, 2009), mutual understanding (Plewa et al., 2013, Bruneel et al., 2010) and firms R&D commitment (Bjerregaard, 2010) are important factors in effective university-industry collaboration. However, the literature on university-industry collaboration is underdeveloped and seems relatively fragmented, as the findings of the existing literature do not directly build on one another by using specific theoretical concepts to develop robust theory. Using the specific theoretical concepts of social capital and proximity dimensions, this thesis contributes to strengthening

the robustness of the literature on university-industry collaboration, which will likely facilitate the ability of future research to build on this research and on the prior literature. The theoretical contribution in this thesis is threefold, relating to proximity, social capital and, finally, the theoretical integration of these two concepts.

5.3.1 Proximity dimensions

First, this thesis contributes to the literature on university-industry collaboration by adopting the theoretical concept of proximity dimensions. In particular, the previous literature on proximity describes the dimensions of proximity that facilitate the formation of collaborations, whereas less attention has been devoted to the interplay and evolution of different dimensions of proximity over time (Balland et al., 2014, Mattes, 2012). Further, the previous literature on proximity in university-industry collaborations has been cross-sectional and quantitative in nature and has examined the factors that lead to the establishment of collaborations. According to Balland et al. (2014), prior studies have mostly analyzed proximity over short periods and have used a static approach. Balland et al. thus suggests using a more dynamic perspective because proximities likely change over time. In addition, previous empirical studies have focused on only one dimension of proximity (Heringa et al., 2014). By contrast, this thesis adopts a more dynamic approach by conducting an in-depth investigation of the development of the concept of proximity in university-industry collaboration. Further, the study uses longitudinal data to show how several proximities within university-industry collaborations emerge and evolve over time.

Moreover, firm-level studies sometimes overlook the fact that the same firm may have both successful and unsuccessful university-industry collaborations involving a variety of collaboration partners, and they may therefore miss important dynamics in the collaborations. By differentiating between science-based and engineering-based firms, this thesis shows how firms' use of different combinations of proximities for innovation depends on contextual factors.

5.3.2 Social capital

Second, this thesis contributes to the literature on university-industry collaboration by adopting the theoretical concept of social capital. Previous research on social capital is typically conducted at a single level of analysis (Adler and Kwon, 2002) that focuses on individuals (Burt, 1992), organizations (Tsai, 2002), communities or nations (Putnam, 1993), and it has failed to evaluate the different meanings, antecedents, and levels of social capital (Adler and Kwon, 2002). There is a call for research using a multilevel analysis by focusing on different level of analysis for purposes of fully understanding the role of social capital (Payne et al., 2011, Hitt et al., 2007). This thesis contributes to the literature on social capital by adopting a multilevel construct of social capital with three levels: the individual, organizational and alliance levels. Moreover, the interplay between the different dimensions of social capital over time has rarely been addressed by empirical studies (Payne et al., 2011), and there is a call for more research on how the different dimensions of social capital interact (Lee, 2009, Rass et al., 2013). Using longitudinal data, this thesis shows how the dimensions of social capital interplay and develop over time depending on firms' level of prior experience with PRO collaboration.

5.3.3 Integration of social capital and proximity dimensions in university-industry collaboration

Based on the included articles, this thesis contributes to the literature by theoretically integrating the concepts of proximity and social capital to find similarities and differences—in addition to strengths and weaknesses—between them and to gain insight into the conditions and contexts in which they are most suitable for fostering university-industry collaboration.

5.3.3.1 Similarities and differences between social capital and proximity dimensions

Figure 5-1 maps the similarities between the dimensions of proximity (i.e., geographical, institutional, organizational, cultural, technological, cognitive and social) and the dimensions of social capital (i.e., structural, relational and cognitive), which are used in this thesis. Each dimension is placed in boxes corresponding to the level of analysis: individual, organizational and macro. Both concepts have been previously studied from different levels of analysis (see Table 2-2); however, this thesis concerns the development of social integration mechanisms in university-industry collaboration to foster firm innovations. Therefore, each of the concept dimensions is positioned according to the level of analysis that I find to be the most suitable for fostering university-industry collaboration. The lines between the boxes illustrate direct linkages between the dimensions.

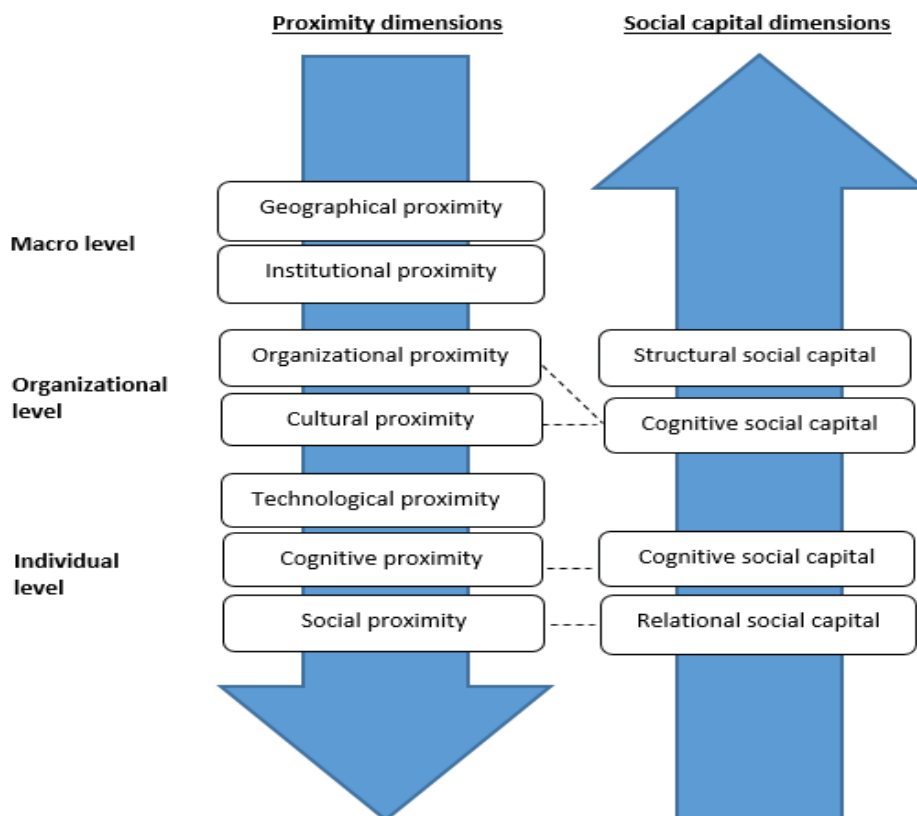


Figure 5-1 Linkages between proximity dimensions and social capital dimensions in university-industry collaboration

The concepts of social capital and proximity dimensions originate from two different traditions, sociology and regional studies. Social capital originally related to interactions between individuals, whereas proximity traditionally related to physical space. Both concepts focus on interaction, but the observations from my papers illustrate that the social capital and proximity concepts begin from different levels of analysis. As the arrow in Figure 2 illustrates, the proximity concept relates to geographical proximity (macro-level) and its influence on mechanisms underlying interaction (individual-level); being physically close fosters personal relations and common understanding between individuals. Geography (macro-level) may be considered the strongest driver of university-industry collaboration at the individual-level because physical closeness facilitates interaction among collaborative partners (Torre, 2008). The arrow for the social capital concept points in the opposite direction because social capital mainly functions through individual-level influences on overall organizational structures; personal relations foster organizational structures such as university-industry collaboration. As opposed to the findings for the proximity concept, I thus find that the individual (individual-level) is the strongest driver of university-industry collaboration at the macro level. The overall difference may be that social capital concerns *how interactions influence structures* in university-industry collaboration, whereas the proximity concept, by contrast, concerns *how structures influence individuals* in university-industry collaboration. Although the two theoretical concepts are different with respect to their backgrounds, the driver for understanding university-industry collaboration and level of analysis, they somehow have become closer, mainly because they both concern interactions in university-industry collaboration (Boschma, 2005, Nahapiet and Ghoshal, 1998). To understand how the concepts are related, I further discuss the linkages and differences among the dimensions of social capital and proximity used in this thesis and provide a discussion of the theoretical concepts related to different level of analysis.

At the *individual level*, the dimensions of social, cognitive and technological proximity and cognitive and relational social capital are observed to be well-suited to individual-level studies on university-industry collaboration because all these dimensions include social and cognitive aspects related to relationships between individuals within organizations. When the linkages between the dimensions are mapped at the individual level, relational social capital and social proximity are strongly connected, as both dimensions focus on personal relations, prior contact and trust between partners in university-industry collaboration and as both dimensions constitute key mechanisms for valuable collaboration (Van Wijk et al., 2008). The dimensions of cognitive proximity and cognitive social capital are related because they both focus on the positive influence of common understanding and similar knowledge bases on university-industry collaboration. In addition to the social and cognitive aspects, technological proximity is important at the individual level for understanding collaborative partners' knowledge bases in university-industry collaboration and thus for exploring knowledge. In focusing on the concept of social capital, the ability to obtain a deep understanding of how partners' different and similar knowledge bases influence university-industry collaboration might be lost because social capital does not capture collaborative partners' technological knowledge bases as precisely as the proximity concept.

Second, at the *organizational level*, the dimensions of cultural and organizational proximity and structural social capital all focus on aspects that are useful in firm-level studies on management structures, organizational cultures and formal structures in PRO collaborations. Cognitive social capital (capturing shared culture) and cultural proximity are related because they both concern the positive influence of similar organizational cultures for university-industry collaboration. In addition, cognitive social capital and organizational proximity are linked because they both concern common goals and norms between organizations, which are valuable for university-industry collaborations. However, the main difference between the

social capital dimensions and the proximity dimensions might be that the proximity dimensions provide a more nuanced framework to understand the organizational level of university-industry collaboration through two dedicated proximity dimensions. Cognitive social capital is included at the organizational level through “cultural similarities” and “shared goals” in university-industry collaboration. To obtain a more complete understanding of the differences and similarities between collaborative partners, the social capital concept might have included aspects from the organizational proximity dimension, such as shared norms and values. Structural social capital is also included at the organizational level, as it concerns the formal structure of university-industry collaborations (i.e., the diversity and stability of the connections); thus, it is a useful dimension to understand the overall pattern of collaborative connections. The proximity concept does not capture the formal structures of collaborations, rendering mapping content (cognitive and relational social capital) on specific university-industry collaborations more challenging.

Several linkages are observed between the social capital and the proximity concepts at the individual and organizational levels related to university-industry collaboration, whereas the main difference is observed at the macro level. The dimensions of geographical and institutional proximity are categorized at the *macro level* because it is valuable to focus on overall structures when studying university-industry collaboration, such as geography and laws, which are difficult to observe through an individual or organizational lens. The social capital concept does not capture the same macro-level concerns (such as laws and norms) as the proximity concept. Thus, research focusing on the social capital concept might fail to evaluate how overall structures influence university-industry collaboration.

Although each of the concept dimensions is categorized at a certain level of analysis, the different levels mutually influence one another in university-industry collaboration. Macro-level dimensions influence the organizational- and individual-level dimensions. For example, the overall laws and geography influence how

organizations coordinate their actions (Knoben and Oerlemans, 2006), and individuals in an organization likely influence the organizational norms and culture as well as the structure of the firm's university-industry collaborations. Moreover, individuals in organizations establish collaborative linkages with other organizations and thus create organizational social capital (Inkpen and Tsang, 2005). Because the levels of analysis for both the social capital and the proximity concepts mutually influence one another, multi-level studies on university-industry collaboration are important. However, by adopting the dimensions of either social capital or proximity presented in Figure 2, a multi-level analysis of university-industry collaboration is consequentially engaged in.

5.3.3.2 Strengths and weaknesses of social capital and proximity dimensions

Based on the discussion of differences and similarities between social capital and proximity dimensions, Table 5-2 summarizes each of the concepts' strengths and weaknesses for exploring university-industry collaboration.

Table 5-2 The strengths and weaknesses of social capital and proximity dimensions for studying university-industry collaboration

	Social Capital	Proximity dimensions
Strengths	Offers dimensions that clearly capture the “formal structures” and the “content” of university-industry collaborations	Capture individual, organizational and macro-level dimensions that influence university-industry collaboration
	Includes dimensions that provide an in-depth understanding of the value of individuals in fostering effective university-industry collaboration	Provide a nuanced framework that covers several aspects of university-industry collaboration
		Capture collaborative partners’ knowledge bases through technological proximity
Weaknesses	Has a limited focus on macro-level dimensions that influence university-industry collaboration	Comprise several dimensions, which can obfuscate the dimension that is appropriate for a particular study
	Lacks geographical and institutional dimensions, which are particularly relevant when firms face common challenges	Lack the ability to capture underlying structures in organizations, such as shared goals and visions
	Lacks a dimension that captures collaborative partners’ knowledge bases	Do not illustrate which dimensions capture “formal structures” and the “content” of university-industry collaborations

Social capital and proximity dimensions have certain complementarities, as some weaknesses in one concept appear as strengths in the other concept; thus, they are suitable for exploring different aspects of university-industry collaboration. One of the strengths observed in the proximity concept is that it captures the macro level of university-industry collaboration; therefore, it is suitable for exploring how overall structures (such as geography) influence organizations and individuals. Moreover, it is suitable to investigate the “status quo” of university-industry collaboration. For instance, macro-level dimensions of proximity might explain why firms in a specific region have limited connections with PRO partners. For example, because of geographical distances to potential PRO partners (Boschma, 2005) and institutional distances, such as common “established practices” (Edquist and Johnson, 1997)

among firms in a region, R&D collaboration may not be the best solution for enhancing a firm's innovation performance. The overall "structures" are somehow influenced by the proximity concept, which makes it suitable to study how a certain structure affects organization and individuals with respect to R&D orientation.

One strength of the social capital concept is the ability to capture both the "formal structure" and "content" of connections within university-industry collaboration, which is particularly useful for understanding the direct effects of interactions among individuals on university-industry collaboration and the role of individual social capital in building organizational social capital. For instance, the social capital concept is useful for exploring how firms can achieve increased connections with collaborative PROs and how individuals enhance these structural connections. Whereas the proximity concept is suitable for exploring the status of university-industry collaborations, the social capital concept is likely more suitable for understanding how increased and better university-industry collaboration can be achieved. Related to the example of firms within a specific region, studying social capital might offer insights into how a region can foster university-industry collaboration.

5.4 Practical implications

R&D collaboration is beneficial for innovation development (Dahlander and Gann, 2010), but it is a challenging task (Ambos et al., 2008). This study has identified potential pathways through which firms can successfully collaborate with PROs to generate innovation by developing social integration mechanisms and the ability to manage firm-level relationships. Different dimensions of proximity and social capital facilitate university-industry collaboration and innovation development. Building proximity dimensions creates similarities and closeness between firms and PROs (Boschma, 2005, Knoben and Oerlemans, 2006), and development of social capital creates common goals and social relationships (Inkpen and Tsang, 2005), both of

which are important for increasing collaborative innovation performance. This thesis extends research on social integration mechanisms in university-industry collaborations by contributing to theory on *how* social capital and proximity dimensions are developed. The findings in this thesis thus have important implications for firms, universities, PROs, policy makers and regions regarding the development of social capital and proximity dimensions to increase innovation development in university-industry collaboration. Next, the implications for firm, PROs, policy makers and regions are discussed.

5.4.1 Implications for firms

To capitalize on firms existing relationships and to be able to create efficient new relationships, firms must understand how to manage and organize their social relationships. First, to develop the dimensions of social proximity and relational social capital, which is one of the key mechanisms for managing successful university-industry collaborations involving trust (Van Wijk et al., 2008), dedicated involvement and contribution from the firm`s side are essential. Although active engagement is a costly strategy, firms will likely receive greater benefit from investing resources over time in line with their interests.

Firms and PROs often have different interests, understandings and goals related to university-industry collaboration, which might hinder communication. Firms should be aware that collaborations with academics are associated with challenges that differ from those arising in collaborations with suppliers and customers, for instance (Perkmann et al., 2013). To enhance mutual understanding, good communication and shared goals, partners should build cognitive proximity and cognitive social capital through dialogue early in the collaboration process, where the partners can clarify their expectations, ask question and obtain an understanding of their different goals and requirements. As such, the awareness of differences might increase, which can ease the process of formulating shared goals for the collaboration

that are beneficial to both partners. This thesis shows that when collaborations are established and when firms have signed collaborative contracts and received grants from support schemes, some firms expect to have immediately achieved the “gold ticket” to innovation, without any appreciable contribution. Nevertheless, university-industry collaboration is a two-way engagement and requires contributions from both partners. Firms should therefore attenuate unrealistic expectations and be patient because it takes time to manage successful and vigorous collaborations with research partners to develop innovations. However, innovation development is likely more rapid when firms are conscious about potential challenges and the value of the engagement and when they have a mutual understanding of the interests of each. Accordingly, firms should be aware that academics have interests related to the academic benefits of collaboration, which are important to take into account when establishing collaborations with PROs (Perkmann et al., 2013).

Further, this thesis shows that firms should build social capital and proximities at all levels within the organization to enhance university-industry collaboration. To do so, firm leaders should more explicitly focus on motivating employees to build networks with PRO partners and internally integrating support mechanisms for employees who participate in university-industry collaboration. Moreover, it might be useful for firms to develop a system in which individual social capital and proximity dimensions are transferred to an organizational level, which would likely strengthen firms’ R&D robustness and reduce the potential vulnerability of relying solely on individuals with certain proximities and social capital dimensions with PROs.

To enhance social capital and proximity dimensions at several levels, firms might use different strategies depending on their firm characteristics. Firms with higher levels of R&D experience are typically considered to possess absorptive capacity, and they benefit more from such collaborations in terms of innovative performance. These firms can use their firm-level social capital and proximities to establish relationships with relevant PRO partners. Firms with lower levels of prior

experience must organize their social relationships with PROs differently. Because of their limited R&D experience and lower levels of common understanding with PROs, firms with less R&D experience may compensate for this by relying on social relationships at the individual level and by transferring it to an organizational level. Firms with less R&D experience have a narrower set of collaboration partners to choose from, but they may be able to establish equally successful collaborations as their more experienced counterparts. Moreover, less experienced firms may develop new collaborations with PROs based on social and geographical proximity, which is a relatively cheaper and faster strategy than heavily investing in internal R&D to achieve greater closeness with PROs. Based on social and geographical proximity, such firms may later partner with other unknown and geographically distant PROs. However, this strategy is less flexible because the potential collaboration partners are limited to those PROs with which a firm already enjoys social relations and geographical proximity.

This thesis has studied different research programs and provided implications for firms regarding the type of university-industry collaborative program it might be most beneficial to join. Firms with less R&D experience might gain the most value from starting with R&D programs in which the aim is to develop applied research and in which a PRO is leading the program and providing research assistance throughout the projects. Applied research projects will likely ensure that the topics are most consistent with the firms' interests, and these firms are likely more motivated to engage in collaborations that increase the development of social capital and proximity dimensions with collaborative PROs. This thesis also shows that firms with less R&D experience learn from participating in university-industry collaborations together with competitors with more R&D experience, with which they have more social capital and proximities. Less experienced firms increase their absorptive capacity by accumulating knowledge from competitors with which they have similar technological knowledge, not from their R&D partners. Hence, the knowledge from

the PRO partners might be transferred more easily to less experienced firms through firms with more R&D experience. Over time, when the firms have built more competence related to university-industry collaboration, it might be easier for these firms to participate in R&D projects that are led by a PRO and that aim to innovate through basic research and a more long-term focus. Firms with more R&D experience, by contrast, have greater R&D maturity and can reap the benefits of participating in long-term oriented university-industry collaborations led by a PRO because of their cognitive proximity to PROs.

Finally, this thesis has important implications for competitors facing similar challenges, such as environmental regulations, which can be addressed through common R&D projects. By pooling an industry's R&D funds, these firms will all benefit more than any one firm can benefit on its own. The largest firms invest the most and reap the greatest benefits. However, small firms with low R&D experience gain more knowledge by interacting with larger firms with more R&D experience than they could gain by engaging in R&D alone with their limited R&D resources. Smaller firms should therefore seek larger firms within the same industry with which they share proximities and social capital and should try to form R&D alliances with them. Table 5-3 summarizes the implications for firms.

Table 5-3 Implication for firms

General	Firms with more R&D experience	Firms with less R&D experience
<ul style="list-style-type: none"> • University-industry collaboration is important for innovation development, but only when you know how to manage personal relationships • Be aware that it takes time to build successful collaborations • Be conscious that PROs often have different interests • Engage in early conversations with PROs to clarify expectations and formulate common goals • Create personal relationships with PRO employees • University-industry collaboration requires strong two-way collaborative efforts • Invest in dedicated involvement and contribution from the initiation to the completion of working tasks to gain benefits from invested resources and to ensure that the research partners address the firms' requirements • Involve several employees from the firm in the collaboration • Firms must understand how to manage and organize their social relationships • Build social capital and proximities to collaborative PROs to achieve strong social relationships, trust, shared goals and common understanding. • Build social capital and proximities at all levels of an organization • Internally integrate support mechanisms related to university-industry collaboration • Motivate employees to engage in external social relationships and have a system to transfer these connections to the firm 	<ul style="list-style-type: none"> • Use firm-level social capital and proximities to establish relationships with relevant PRO partners • Make sure that the individuals across organizations develop social capital and proximities over time • Can reap benefits from participating in long-term university-industry collaborations led by a PRO 	<ul style="list-style-type: none"> • Start with geographically and socially proximate PROs • Rely on social relationships at the individual level • By relying on geographically and socially proximate PROs at the beginning of university-industry collaboration, they can build more individual-level social capital and proximity dimensions to develop the organizational level over time • Start with R&D projects that aim to develop more applied research and that are led by the user firm • Collaborate with competitors and other firm partners with more R&D experience • Over time, when the firms have built more competence related to university-industry collaborations, it might be easier for these firms to participate in R&D projects that are led by a PRO and that aim to innovate through basis research with a more long-term focus

5.4.2 Implications for PROs

The most important implication of the findings for PROs seeking to establish R&D collaborations with firm partners is the need to create personal relations with collaborative firm partners that consist of trust and common understanding. This thesis shows that when entering university-industry collaboration, PRO partners often think, “we do what the firms want us to do”. Nevertheless, this is not the reality. When entering university-industry collaboration, PROs should take the time to become familiar with their firm partners, their expectations and their aims related to the collaboration. PROs should also be aware that firms and PROs may have different interests and should be aware of the importance of capturing these interests at the beginning of the collaboration. Doing so will likely increase the value of the collaboration and the ability to manage innovation outcomes faster. Hence, PROs should engage firm partners early in the process of establishing collaborations and should ask questions and listen to the firms to obtain an understanding of firms’ expectations. PROs should acknowledge that successful university-industry collaboration is a long-term process that begins with developing personal relations and clarifying expectations. It is sometimes challenging to spend time at the beginning of a collaboration to become familiar with one another, but as this thesis shows, this process is important to be able to create effective university-industry collaboration to foster firm innovations. Table 5-4 summarizes the implications for PROs.

Table 5-4 Implications for PROs

Implications for PROs in university-industry collaboration
<ul style="list-style-type: none">• Create personal relationships with firm partners that consist of trust and common understanding• Discuss each partner's desired outcomes from the collaboration• Be proactive in contacting firm partners• Engage firm partners early in the process and involve them in formulating goals• Visit firm partners frequently• Be aware that there are different interests between different firms and the PROs• Ask questions and listen to the firms to obtain an understanding of the firms' expectations• Clarify technical concepts

5.4.3 Implications for policy makers

As its empirical setting, this thesis examines three public research programs supported by the Research Council of Norway. Thus, the findings of this thesis have important implications for how policy makers can design such programs to increase innovation outcomes and facilitate successful university-industry collaborations. Hence, policy makers play a central role in facilitating research funding to increase the development of social capital and proximity dimensions in university-industry collaboration, which is important for innovation development.

Because of the importance of social relations between firms and PROs for the innovation development highlighted in this thesis, policies might be formulated to include a preliminary project in which partners from industry and PROs establish the framework conditions for collaboration to ensure common understanding and shared goals before entering the collaboration. A preliminary project may lead to a greater firm influence on working topics within university-industry collaborations, may prevent firms from exiting the collaborations because of a lack of industry focus, and may contribute to more rapid innovation development and increased utilization of project funds. Moreover, governments should encourage PRO partners to be proactive in contacting firm partners. Such contacts will foster the personal relationships and trust that are necessary for long-term, successfully university-

industry collaborations. These initiatives will likely promote the development of the relational and cognitive dimensions of social capital and proximity, which are crucial both at the beginning of a collaboration and over time.

A central finding of this thesis is that it takes time to build social capital and proximity dimensions in university-industry collaboration, which indicates that a long period of time is necessary for the development of immature radical innovations in university-industry collaborations. Firms and PROs need time to achieve a common understanding and to create personal relations to establish common working conditions in which all partners' requirements are met, which this thesis finds are essential for developing innovations. A long time horizon for policy, firms and PRO actors is important, and policy makers should demonstrate patience with respect to innovation development. A possible consequence for university-industry collaborations with a short time horizon might be that the collaboration process may finally begin to function well when only limited time remains for the project. This may hinder future applicable results for both firms and PROs that have just received the funding required for technological innovations. Although immature innovations need a long time to develop, it might be valuable to focus on short-time goals early in the collaboration process. A policy requirement could therefore be to formalize what the collaboration aims to achieve over the next 10 years and in every second year from the beginning of the collaboration. University-industry collaborations aiming at more incremental innovations may need shorter time periods for innovation development. However, to develop personal relations, to clarify the expectations of the firm and the PRO partner and to formulate goals, a preliminary project prior to the collaboration would be useful for short-term collaboration aiming at the development of incremental innovations.

To ensure that firms and PROs manage to achieve increased social capital and proximity dimensions during university-industry collaboration, policy makers might implement more and earlier evaluations by evaluating not only innovation outcomes

but also the development of social capital and proximity dimensions in collaborations. For example, a mid-term evaluation was used in the FME program after three years, which was useful to reveal challenges and generate suggestions for solutions to achieve a more valuable collaboration. However, an earlier evaluation would likely expedite the process of developing innovation.

This thesis has explored different types of research programs, and the findings have policy implications related to hosting university-industry collaborations. When the aim is to develop immature and more radical innovations, PROs might lead the collaboration because they are more concerned with basic research. For the development of radical innovations, firm partners with R&D experience that have cognitive proximity to PROs and economic robustness should participate. When the aim is to develop incremental innovations, firm partners might host the research projects because they are more concerned with applied research, and hosting research projects will inspire them to become more involved in the projects and facilitate the development of social capital and proximity dimensions. However, as observed in the study of a coopetition alliance consisting of firms with higher levels of R&D experience and firms with lower levels of R&D experience, firms with less R&D experience could start with small and applied research projects hosted by PRO partners, which provide research assistance throughout the projects. Over time, when their R&D orientation increases, these firms would likely increase their ability to host future research projects.

Furthermore, when designing R&D support schemes, policy makers should be aware that firms invest in R&D differently depending on their characteristics. Firms with less R&D experience and lower levels of absorptive capacity tend to build on social and geographical proximity when selecting their PRO partners. More experienced firms with higher levels of absorptive capacity tend to use government grants as tools to build social proximity and further strengthen their cognitive and organizational proximity to leading PROs in their field. Hence, different policies

targeting increased collaboration between firms and PROs may be adopted depending on whether the aim is to increase the number of firms collaborating with PROs or to expand the extent of the collaboration. Accordingly, policy makers should be aware that building firms' R&D orientation to increase innovativeness is a time-consuming process that requires mobilization. Policy makers should therefore aim to increase the use of R&D mobilization projects and research-based brokering, which facilitates interaction between firms and PROs and thus contributes to developing links between firms and potential R&D partners for innovation development.

Finally, this thesis has important implications for coopetition policy because it explores a coopetition alliance in which competing firms and PROs collaborate on common R&D projects. Coopetition alliances can be difficult to establish because of antitrust laws, and governments that seek a more sustainable future should develop regulations that ensure that competing firms can cooperate—particularly with respect to environmental issues. The next step might be to develop dedicated financial measures directed toward environmental R&D within coopetition alliances. Such measures might encourage more firms to cooperate on environmental issues and might also ensure that both large firms with R&D experience will increase their knowledge and smaller firms with less R&D experience will have access to important knowledge. The policies could be formulated to include firms of different sizes and with different technological capabilities. The purpose of including smaller firms would be to encourage both the development of basic process knowledge and the environmental development of an entire industry rather than leaving this responsibility to the largest and most developed firms. The focal firms in the coopetition alliance in this thesis compete in a global market, and by participating in a national coopetition alliance, they may enhance overall industry knowledge at the national level and thereby increase their competitiveness in the global market. Table 5-5 summarizes concrete guidance for firms, PROs and policy makers with respect to

successfully university-industry collaborations aimed at generating knowledge and innovations.

Table 5-5 Implications for policy makers

General	Special areas
<ul style="list-style-type: none"> • Engage firm partners early in the process of establishing collaborations by requiring firm-partner involvement • Include a preliminary project in which partners from industry and PROs establish the framework conditions for the collaboration to ensure a common understanding and shared goals before entering the collaboration • Encourage PRO partners to be proactive in contacting firm partners • Require short-term and long-term goals to be formulated in collaboration between firms and PROs • Clarify the concept of innovation • Implement more and earlier evaluations of collaborations • Adopt different policies for increased collaboration between firms and PROs depending on whether the aim is to increase the number of firms collaborating with PROs or to expand the extent of the collaboration • Facilitate interaction between firms and PROs through increased use of R&D mobilization projects and research-based brokering 	<ul style="list-style-type: none"> • Type of innovation: <ul style="list-style-type: none"> • Development of immature radical technologies <ul style="list-style-type: none"> ○ Long-term projects ○ PROs hosting the projects ○ Engage firms with R&D experience, economic robustness, and an understanding of the value of long-term research • Incremental innovations <ul style="list-style-type: none"> ○ Shorter time periods for the development ○ Firm partners hosting the projects • Environmental R&D projects <ul style="list-style-type: none"> ○ Long-term projects ○ Engage firms with R&D experience at the beginning ○ Develop regulations that ensure that competing firms can cooperate on environmental issues ○ Develop dedicated financial measures directed toward environmental R&D within coopetition alliances

5.4.4 Implications for regions aiming to become more R&D oriented

In addition to the implications derived from the individual and organizational level of analysis, this thesis has implications for regions aiming to become more R&D oriented. A motivation for the topic of this thesis was to gain knowledge about how industrial firms in my home region could become more R&D oriented and achieve higher innovation outcomes. One of the challenges in university-industry collaboration is the lack of social capital and proximity dimensions—including geographical, cognitive and

social dimensions—with PROs, which prevents some firms from engaging in university-industry collaborations. To overcome such challenges, firms in a region should strive to build social capital and dimensions of proximities to gradually increase the understanding of the value of university-industry collaboration in the region and to develop relationships with potential PRO partners, which will likely increase the ability of firms to engage in university-industry collaborations. To increase R&D activity in a region, local government, industry and R&D institutions might develop better connections and better cohesion. These actors could collectively establish an R&D-related vision for the entire region and specific goals, strategies and actions to achieve this vision; thus, several actors in the region would be working in a common R&D direction. The local government, industry and research and development institutions might then develop knowledge regarding why university-industry collaborations are important and how firms can engage in R&D and further convey this knowledge to firms. Moreover, these actors should develop a network of potential PROs and bridge the network to firms within the region. Through such a network, these organizations might build some level of social capital and proximity dimensions with PROs, which could be transferred to local firms.

5.5 Limitations and implications for further research

This thesis has several methodological and theoretical limitations, which provide potential avenues for further research on university-industry collaborations. First, this thesis is based on empirical data from the specific context of research programs supported by the Research Council of Norway. Although the findings of this thesis might be transferable to other types of university-industry collaborations and other R&D programs, they are not universally valid, and they are not directly transferable to other contexts. To increase the international transferability of the findings, further research might explore research programs outside the context of Norway.

To obtain an in-depth understanding of how social integration mechanisms are developed in university-industry collaborations to foster firm innovations, a qualitative case study design was adopted (Eisenhardt, 1989). However, the number of cases is too small to represent a larger population of actors in university-industry collaboration (Yin, 2014). Future research should test the findings of this thesis by using larger samples to explore whether the findings are transferrable to other university-industry collaborations and to generalize the findings to a wider population. The papers included in this thesis develop theoretical propositions that may be critical for using and testing my results in future quantitative studies (Yin, 2014).

To obtain information regarding specific types of university-industry collaborations between firms and PROs, this thesis drew on a sample from university-industry collaborations supported with grants from the Research Council of Norway. The empirical setting of R&D collaborations supported by government grants was useful for identifying relevant cases and obtaining access to data. However, the presence of grant funding might have influenced firms' behavior. In the cases investigated in this thesis, it seems clear that the firms are collaborating with PROs to a greater extent than other firms because of the grants. This context was suitable for studying how firms collaborate with PROs because it provided a number of cases in which less-experienced firms entered such collaborations. Hence, I believe that the theoretical mechanisms identified in this study regarding how the collaborations unfolded are not significantly influenced by the existence of government grants. However, whether and how less experienced firms would initially engage with PROs independently of such support warrants further study.

The longitudinal data from two of the data sets (FFF and FME) included in this thesis clearly illustrate that collaborations between firms and PROs are path dependent and that they often change in character over time. Hence, additional longitudinal studies are needed to capture the dynamic aspects of such collaborations

and to specify how certain conditions, instances, and underlying processes develop over time in university-industry collaborations (Yin, 2014). A further limitation is that this study mainly includes successful cases of university-industry collaboration in which firms have managed to accumulate knowledge from PROs and develop innovations. The inclusion of only successful collaborations in two of the articles in this thesis, however, impedes the determination of whether some of the characteristics of successful collaborations also apply to unsuccessful collaborations. Although the aim of this thesis was to unravel the mechanisms behind—rather than to predict—successful university-industry collaborations, further research is warranted to explore the differences between university-industry collaborations with different outcomes. Future studies should therefore use long-term outcome measures and include both successful and unsuccessful collaborations to better understand the effects of different proximity and social capital dimensions.

From the case investigation of this thesis, the research team that I participated in when studying the BIPs observed that the innovation projects in two of the articles in this study were typically highly interrelated with other preceding or succeeding innovation projects, often with similar collaboration partners. Although using projects as the unit of analysis increased the closeness of the analysis to the actual collaboration, both qualitative and quantitative research on projects should account for the interrelated nature of innovation R&D projects. Another limitation of this thesis relates to the articles on research alliances in which firms within the alliances were used as the unit of analysis. These studies do not evaluate the alliances as the unit of analysis and do not make cross-alliance comparisons. Further studies should include research alliances as the unit of analysis and select a larger number of cases to be able to make cross-case comparisons between research alliances.

This thesis also has some theoretical limitations. By focusing on the particular theoretical concepts of social capital and proximity dimensions, I may overemphasize some mechanisms, fail to recognize other mechanisms or downplay other factors that

are useful for understanding how social integration mechanisms are developed in university-industry collaborations to foster firm innovations. Thus, there is a need for research using other theoretical concepts related to how firms and PROs manage successful university-industry collaboration. Other researchers may then use my data to explore university-industry collaboration by building on other theoretical concepts. Furthermore, there may be an opportunity to triangulate the concepts of social capital and proximity dimensions in the same study to address how the concepts are complementary in addressing university-industry collaboration.

This thesis also has some limitations regarding the use of the concepts of social capital and proximity dimensions. First, I believe that future research can further elucidate the conceptual development of the different proximity dimensions and the relationships between them. For instance, dimensions such as social and—to some degree—cognitive proximity appear to be linked to the individual level of analysis, whereas dimensions such as cultural and organizational proximity are more closely related to the organizational level. Understanding these differences may help firms to develop and maintain successful collaborations with PROs and to avoid collaborations that are overly dependent on individual relationships. Future research should thus explore proximity dimensions in multi-level studies to explore how proximity is developed and transferred between different levels, such as individuals and organizations.

Second, the study on social capital provides some key findings regarding the interplay and evolution of social capital that may be specific to the context of innovation projects with PROs. Collaboration for the development of innovations seems to involve fewer tangible resources and more tacit knowledge than collaboration for other purposes. Hence, relational social capital at the individual level involving trust and personal support will be particularly important (Moran, 2005) to consider in future studies. The findings related to social capital in university-industry collaborations illustrate that social capital should be developed at several levels,

including the individual, organizational and the university-industry collaborative level. Hence, I show the importance of conducting multi-level studies on social capital in future research (Payne et al., 2011, Hitt et al., 2007).

Further, I observed that over time, some firms developed an open relationship with selected PROs that was characterized by close interaction. In these cases, the organizational boundaries were ambiguous during the innovation processes that I studied. The extent to which a firm's border was open in the innovation process was clearly dependent on the level of social capital. This finding warrants further study. Social capital is a useful concept for studying university-industry collaboration, and there is a clear need to better understand the social capital mechanisms underlying university-industry collaboration and their dynamics over time.

6. References

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Appendix A. Conceptualization of the literature on university-industry collaboration

Title	Journal	Author and year
The institutionalization of knowledge transfer activities within industry-university collaborative ventures.	Journal of Engineering and Technology Management	(Santoro and Gopalakrishnan, 2000)
The Application of External Knowledge: Organizational Conditions for Exploration and Exploitation.	Journal of Management Studies	(Bierly et al., 2009)
Gaining from interactions with universities: Multiple methods for nurturing absorptive capacity.	Research Policy	(Bishop et al., 2011)
Industry and academia in convergence: micro-institutional dimensions of R&D collaboration.	Technovation	(Bjerregaard, 2010)
Playing the collaboration game right - balancing trust and contracting.	Technovation	(Blomqvist et al., 2005)
Investigating the factors that diminish the barriers to university-industry collaboration.	Research Policy	(Bruneel et al., 2010)
Collaborative research programmes: building trust from difference.	Technovation	(Davenport et al., 1999)
Factors affecting university-industry R&D projects: The importance of searching, screening and signalling.	Research Policy	(Fontana et al., 2006)
What drives the formation of 'valuable' university-industry linkages? Insights from the wine industry.	Research Policy	(Giuliani and Arza, 2009)
Exploring Social Network Dynamics Driving Knowledge Management for Innovation.	Journal of Management Inquiry	(Gubbins and Dooley, 2014)
Technology transfer between basic research and industry.	Technovation	(Hameri, 1996)
The effect of institutional proximity in non-local university-industry collaborations: An analysis based on Chinese patent data.	Research Policy	(Hong and Su, 2013)
The impact of cognitive communities on the diffusion of academic knowledge: Evidence from the networks of inventors of a French university.	Research Policy	(Hussler and Ronde, 2007)
R&D cooperation and failures in innovation projects: Empirical evidence from French CIS data.	Research Policy	(Lhuillery and Pfister, 2009)
Different dimensions of knowledge in cooperative R&D projects of university scientists.	Technovation	(Niedergassel and Leker, 2011)
The impact of technological relatedness, prior ties, and geographical distance on university-industry collaborations: A joint-patent analysis.	Technovation	(Petruzzelli, 2011)
The evolution of university-industry linkages-A framework.	Journal of Engineering and Technology Management	(Plewa et al., 2013)
Collaborating - How to get the most from university relationships	Mit Sloan Management Review	(Wright, 2008)
Partnering with universities: a good choice for nanotechnology start-up firms?	Small Business Economics	(Wang and Shapira, 2012)
Beyond industry-university links: Sourcing knowledge for innovation from consultants, private research organisations and the public science-base.	Research Policy	(Tether and Tajar, 2008)
Knowledge acquisition in university-industry alliances: An empirical investigation from a learning theory perspective.	Journal of Product Innovation Management	(Sherwood and Covin, 2008)