



The interplay of cognitive and relational social capital dimensions in university-industry collaboration: Overcoming the experience barrier

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ABSTRACT

The use of university-industry collaboration in the innovation process is viewed as a major driver of firm competitiveness. The organizational dynamics underlying successful external relationships, however, remain poorly understood. Using longitudinal case studies of 15 innovation projects, we examine how firms with varying degrees of experience in collaborating with universities and public research organizations rely on different social capital dimensions to achieve successful collaborations. We find that experienced firms establish external collaborations on the basis of cognitive social capital, but this basis is reinforced by relational social capital over time. Conversely, less experienced firms initially base their university collaborations on relational social capital, which is reinforced by cognitive social capital over time. Based on these findings, we theorize on the interplay of different dimensions of social capital in university-industry collaborations over time. Our study has important implications for the management of collaborative innovation projects. In particular, it provides guidance to enable less experienced firms to develop successful collaborations with university partners.

1. Introduction

Many firms find it difficult to develop new innovations (Katila and Ahuja, 2002), and innovation studies have emphasized the importance of external sources of knowledge to complement internal knowledge (Chesbrough, 2003; Chesbrough et al., 2006; Von Hippel, 1988). One important source of external knowledge comprises universities and public research organizations (henceforth universities), which provide technological know-how and expertise to firms engaged in innovation development (Cohen et al., 2002). This trend is evidenced by the growing number of research alliances and joint research centers involving both firms and universities (Boardman and Gray, 2010). There have been frequent reports of tensions between academic and commercial activities (Ambos et al., 2008), however, and of organizational barriers in university-industry collaborations (Bruneel et al., 2010). Still, there has been little systematic research into how such barriers are overcome as relationships between firms and universities evolve over time (Ankrah and Al-Tabbaa, 2015; Estrada et al., 2016).

The literature has emphasized the importance of pre-existing relationships in overcoming these barriers and successfully collaborating across organizational boundaries (D'Este et al., 2013; Gulati et al., 2009; Kavusan et al., 2016). Prior relationships are considered important because they create social capital, which facilitates the transfer

of knowledge between partners (Inkpen and Tsang, 2005). Social capital has been defined as “[t]he sum of the actual and potential resources embedded within, available through and derived from the network of relationships possessed by an individual or social unit. Social capital thus comprises both the network and the assets that may be mobilized through the network.” (Nahapiet and Ghoshal, 1998, p.243). These relationships are not uniform, however, and new collaborative partnerships require time to develop different dimensions of social capital. Cognitive and relational dimensions have been identified as crucial for facilitating inter-organizational knowledge transfer (Van Wijk et al., 2008). Cognitive social capital is important for the development and exchange of knowledge, and it is related to shared meaning and mutual understanding between collaborative partners (Nahapiet and Ghoshal, 1998). Relational social capital refers to those resources created through actors’ interactive relationships, building on, for instance, a high level of trust between partners (Al-Tabbaa and Ankrah, 2016).

There is a clear gap in the literature regarding how firms develop social capital by partnering with university researchers, particularly when firms lack prior collaborative experience with universities. Hence, this paper explores the following research question: *How do firms with varying degrees of prior collaborative experience with universities develop the social capital necessary to collaborate successfully with university researchers to develop new innovations?*

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Social capital is typically built through interaction over time. Hence, we conducted a longitudinal case study mapping the initiation, development, and outcome of 15 successful innovation projects conducted by Norwegian firms and that involved university collaboration. All the innovation projects developed new or improved products or processes that the firms' ex post evaluated as highly profitable. To investigate how prior experience influences the development of social capital in university-industry collaborations, we selected cases with varying degrees of cognitive social capital referring to the level of prior university collaborations and academic expertise (e.g. employees with a PhD degree). We relied on the extended case study method, whereby we re-conceptualized and extended theory based on empirical data gathered through case studies (Burawoy, 1998; Danneels, 2011; Wadham and Warren, 2014).

By studying how different dimensions of social capital interact and evolve over time, we contribute to the research on social capital and university-industry collaboration in several respects. First, we provide new insights into the role of firm characteristics in the use and development of different social capital dimensions. Prior experience in university collaboration and academic expertise has been seen as an important precondition for successful university-industry collaboration because it strengthens the cognitive social capital between partners (Inkpen and Tsang, 2005; Wasko and Faraj, 2005). Our study shows that firms with lower levels of cognitive social capital might compensate by relying on relational social capital when they engage in collaborative projects with university researchers.

Second, we add to the knowledge on the outcomes of social capital by studying the relationships among different dimensions of social capital; further study on this topic has been called for by several authors (Inkpen and Tsang, 2005; Rass et al., 2013). The most notable finding relates to the relationship observed between cognitive and relational social capital. Firms with limited experience with university collaborations and academic expertise build on relational social capital to establish collaborations and then develop cognitive social capital over time. In contrast, more experienced firms with academic expertise can establish their collaborations on the basis of cognitive social capital, which is reinforced by relational social capital over time. These findings provide novel insights into how firms with low levels of prior experience with university collaboration and academic expertise can improve their ability to engage with university researchers in innovation activities. Overall, by adapting the social capital perspective, we outline a more detailed and theory-based understanding of how firms use university researchers as collaborative partners in the development of specific innovations. By studying innovation projects from inception to successful outcome, we add a dynamic understanding of how firms can manage their alliances and build better alliance capabilities (Ireland et al., 2002; Wang and Rajagopalan, 2015).

This article proceeds as follows. Section 2 outlines a theoretical framework based on the role of social capital dimensions in university-industry collaborations. The third section presents the methodological approach used in our study of 15 collaborative innovation projects. Section 4 presents our theory development, which is formalized in propositions, as well as a model of the impact of social capital on effective collaborations between firms and university researchers. Finally, Section 5 outlines the contributions and limitations of the study, as well as its conclusions and implications for managerial practice and future research.

2. The role of social capital dimensions in university-industry collaboration

It is no easy task for firms to identify and assimilate relevant external knowledge sources (Cohen and Levinthal, 1990), and firms face challenges when accumulating knowledge from universities because firms and academic scientists approach problems differently and with different goals (Sauermann and Stephan, 2012). Social processes are

known to strongly influence organizational behavior and effectiveness (Granovetter, 1985; Kwon and Adler, 2014), and the role of social capital in facilitating knowledge transfer has been well documented (Inkpen and Tsang, 2016). Social capital theory offers a meso-level approach to explain how inter-organizational relationships can be used to access knowledge resources.

University-industry collaboration is a form of inter-organizational relationship or network whereby two or more organizations join forces to exchange resources and knowledge for a common purpose. For firms, engaging in inter-organizational collaboration not only provides access to relevant knowledge but also involves engagement in learning networks that produce knowledge that is currently unavailable to the firms (Powell et al., 1996). Different dimensions of social capital may be crucial for knowledge transfer because social capital helps a firm to identify and forge effective relationships with relevant partners (Inkpen and Tsang, 2005; Tsai and Ghoshal, 1998), and social capital is particularly important in university-industry collaborations, in which conflicting logics can impede the relationship (Sauermann and Stephan, 2012; Steinmo, 2015).

In this paper, we investigate specific collaborations between firms and university partners. Following the seminal works of Nahapiet and Ghoshal (1998) and Inkpen and Tsang (2005), we explore the dimensions of cognitive and relational social capital, which refer to personal relationships developed through interaction (Burt, 1992). A third dimension of social capital that is commonly discussed in management research is structural social capital, which refers to the overall patterns of connections, who attains structural capital and how it is reached (Burt, 1992; Lee, 2009). Because we study the development of relationships and interactions that occur in formalized collaborations, however, our focus is on the cognitive and relational dimensions that have been found to be crucial for inter- and intra-organizational knowledge transfers (Van Wijk et al., 2008). Nevertheless, the cognitive and relational social capital dimensions remain less explored in the literature than structural social capital (e.g. Moran, 2005; Petruzzelli, 2011; Rass et al., 2013).

Cognitive social capital refers to shared interpretations and systems of meanings (Cicourel, 1974), common languages 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 each other (Hult et al., 2004). Cognitive social capital has been divided into two categories: shared goals and shared culture (Adler and Kwon, 2002). Shared goals refer to common understandings of and approaches to network tasks (Inkpen and Tsang, 2005) and common views of goals (Masiello et al., 2015). Shared culture refers to rules and norms that determine appropriate behavior in the network. Inkpen and Tsang (2005) emphasized that when actors within a network have cultural linkages, it is easier for them to transfer knowledge. Too much similarity in the cognitive dimension, however, may reduce the potential for innovation in inter-organizational learning, leading to an inverted U-shaped relationship between cognitive social capital and innovation performance (Cowan et al., 2007; Petruzzelli, 2011). The cognitive dimension may be particularly challenging in university-industry collaborations because of differences in culture, language and goals between academia and industry. Hence, firms that invest in internal research and development (R&D) are better able to overcome this barrier and collaborate with universities (Laursen and Salter, 2004) because they develop expertise in the same practice that is found to increase firms' abilities to communicate and share knowledge (Wasko and Faraj, 2005). Moreover, the literature has emphasized the importance of pre-existing relationships for overcoming collaborative barriers across organizational boundaries (D'Este et al., 2013; Gulati et al., 2009; Kavusan et al., 2016). Hence, we operationalize cognitive social capital as the firm's general collaboration experience with universities and academic expertise.

Relational social capital refers to "[t]hose assets created and leveraged through relationships" (Nahapiet and Ghoshal, 1998, p. 244)

and describes personal relationships created through prior contacts (Granovetter, 1992). Relational social capital also concerns mutual respect and trust, relational closeness, expectations, and reputations (Adler and Kwon, 2002). Strong relationships and mutual trust among actors facilitate knowledge transfer (Reagans and McEvily, 2003), increase the willingness to exchange information (Uzzi, 1999), and can offset the negative effects of partner differences (Lavie et al., 2012). People tend to repeat contacts through long-term relationships when they achieve fair rewards for their actions (Murphy et al., 2007). Given the impacts of trust and tie strengths, relational social capital is considered the most important dimension in the facilitation of inter-organizational knowledge transfer (Van Wijk et al., 2008). Firms with high levels of relational social capital with their collaborative partners transfer knowledge easily because this dimension enhances openness to sharing information and decreases transaction costs (Adler and Kwon, 2002). Trust is also an important determinant when firms select collaborative partners because actors are more willing to share resources with an entity they trust (Tsai, 2000), and together with commitment, trust is essential for repeated contacts between partners (Huang et al., 2009). High levels of trust reduce opportunistic behaviors and knowledge-monitoring costs (Putnam, 1993) and often result in meaningful communication between partners (Hazleton and Kennan, 2000). Trust may be particularly salient in university-industry relationships, in which the logics are very different and the partners compete in different arenas (Masiello et al., 2015). Hence, we operationalize relational social capital as prior relationships and collaboration experience between the specific partners.

In the context of university-industry collaborations, social capital may be particularly important, not only to overcome the differences between academia and industry but also because the development and realization of technological innovation are complex processes that require comprehensive collaboration over time. Many studies have explored the types of collaborative relationships associated with innovation and performance, but relatively little is known regarding how fruitful collaborations are established and how they evolve. Generally, the literature has cited the importance of prior collaborative experience, pre-existing relationships and various dimensions of proximity as important factors for success in collaboration (e.g. Boschma, 2005; Steinmo and Rasmussen, 2016). The means through which these firms initially developed these relationships, however, remains unknown. This gap is particularly unfortunate for less experienced firms that, despite their unfavorable status, seek to develop fruitful collaborations with university researchers. Building on the social capital perspective, we examine the process by which firms with varying degrees of prior collaborative experience with universities and academic expertise—and hence varying levels of cognitive social capital—develop the cognitive and relational social capital necessary for successful collaboration with university researchers.

3. Methodology

3.1. Research design

Our research design follows the extended case method by combining existing theory with cases that can verify and challenge this theory (Burawoy, 1998; Wadham and Warren, 2014). Our objective is to advance theory on the development of social capital between university researchers and firms with varying degrees of experience with university collaborations and academic expertise. The knowledge transfer in such collaborations occurs at the local level, that is, between sub-units and teams, rather than between organizations. Hence, there may be significant variety in the extent and type of relationships with universities, particularly within large firms. To capture the actual collaboration processes, we use specific innovation projects as the unit of analysis. Our longitudinal case-study design is suitable for focusing on the interplay among the different dimensions of social capital between

the collaborative partners over time (Pettigrew et al., 2001). This design facilitates richer contextual insights and an in-depth understanding of a process that has scarcely been investigated in prior studies (Eisenhardt, 1989). Multiple case studies provide a stronger basis for theory development (Yin, 1989) because emergent findings can be compared across cases, and the findings may be grounded in varied empirical evidence (Eisenhardt and Graebner, 2007).

3.2. Case selection

The cases were selected from a population of projects that received support from a public scheme that supports high-potential, user-driven innovation projects in Norwegian firms (called BIP). In total, 709 projects received BIP support between 1996 and 2005; each public grant typically covered 20–40% of the total project costs, and the duration of the projects was from two to four years. Each project was managed by a lead firm and included at least one university (in several cases, a public research institute) and often other firms as partners. The university partnership was often linked to individual researchers, rather than a university department. Because we wished to explore successful cases of university-industry collaboration, we selected ex post from among top-performing projects based on the project's contribution to the profits reported by the lead firm four years after completion of the project. Moreover, the selected sample was suitable for identifying different collaborative experiences. University-industry collaborations are typically characterized by well-established linkages, but our cases, which came from a government-supported program, included several projects led by firms that had limited experience with university collaboration and academic expertise. After initial contacts with the firms that managed the 29 highest-performing BIP projects, we were granted access to study 15 projects. At the outset of the projects, 7 cases had extensive prior university collaboration experience and academic expertise, and 8 cases had limited experience and expertise of this type, resulting in differences in cognitive social capital between these groups. The projects were conducted by firms of various sizes, from small start-ups to large industrial firms, thus providing contextual variety (Yin, 1989). Moreover, the projects varied in terms of the industry and type of innovation developed (see Table 1).

3.3. Data collection

Data regarding the pre-start-up and start-up activities of innovation projects are usually scarce. Because the projects in this study received support from a public support program, we were able to obtain comprehensive and similar information about all the cases. The data include archival material, such as the initial project description, final report, and assessments conducted by the public program, as well as survey responses from each firm at the start, at the finish, and four years after the project period ended. In addition, relevant written documentation was collected from outside sources, such as press articles and Web pages.

Furthermore, our primary data comprised interviews with an average of three key persons in each case to obtain an in-depth understanding of how the innovation process unfolded, including interactions between each firm and its university partners (Table 2). In total, we interviewed 40 persons, 32 of whom were interviewed face-to-face and 8 of whom were interviewed by telephone, in October and November 2010. Most of the interviews were conducted with two researchers present. The interviews were recorded and transcribed by the authors as part of the data analysis process. To obtain an in-depth understanding of how the innovation process unfolded in each case, we utilized a narrative approach (Polkinghorne, 1988). The interviewees asked the informants to describe the process from inception to the present with minimal interruptions by the interviewees.

As an overall interview template, our objective was to reveal the history of the project in chronological order, starting with the

Table 1
Firm characteristics and type of innovation developed in the project.

Firm	Size ^a	Type of innovation developed in the R&D project	Interview quotes related to the type of innovation
1 Biotech	Large	New technology	"We managed to transform a high-tech research tool to make it applicable at a lower level"
2 Information and communications technology	Micro	New technology	"This project was the first of its kind in Norway...in retrospect, it turns out that we were the first in the world on this"
3 Large process industry	Large	Improved tool technology	"...we developed a radically new tool technology that improved the duration of tools by 400-500 percent"
4 Large process industry	Large	Improved energy efficiency	"To be competitive, we had to improve our concept, which we succeeded in doing"
5 Science-based	Micro	New technology	"Developed a new method that was cheaper and easier to use than competing technologies"
6 Science-based	Small	Method improvement	"Increased value by developing a more predictable method"
7 Biotech	Micro	New technology	"Diagnostic and treatment methods that can detect disease at an early stage and slow or stop a disease process"
8 Engineering	Large	Technology improvement	"This technology quadrupled efficiency, which has produced a noticeable effect on sales"
9 Large process industry	Large	Technology improvement	"Unfortunately, we had to close down the plant where this technology was implemented, but in the time period between implementation and plant closure, it had a substantial effect"
10 Network, several firms	Small	Improved knowledge in a new business area	"There has been a large increase in the utilization of [Technology X] in Norway...this project has contributed to this increase through both building knowledge and diffusing interest"
11 Engineering	Large	Technology improvement	"Fundamental technological changes to secure market position"
12 Engineering	Medium	New technology	"First product in the market"
13 Engineering	Medium	Organizational (product development and brand improvement)	"It was about building a brand; integrated product development, innovative solution methods and differentiation through industry design"
14 Engineering	Large	New technology	"We developed new technology for a conservative industry and needed a reference installation to convince [customer group] to opt for our technology"
15 Process industry	Large	Technology improvement	"That improvement was worth a lot...over 100 million NOK per year"

^a EU measures of firm sizes are used: large > 250 employees, medium < 250 employees, small < 50 employees, and micro < 10 employees.

background of the initiation of the innovation project, followed by the planning and execution of the project, and finally, the results gained from the project. To obtain further detailed information concerning the critical events and actors involved throughout the process, we used open-ended follow-up questions, such as "Why did you do that?", "Who was involved in this event?", "Did you consider alternative actions?", and "When did this happen?" To avoid biases, the interviewers did not explicitly refer to the theoretical concepts used in this paper. This type of narrative interviewing was conducted to obtain a better

understanding of actual events and to prevent personal views and theoretical perspectives from influencing the data collection. The use of multiple informants and narrative interviewing in combination with historical documentation was crucial to reducing the problems of hindsight bias and memory decay. The aforementioned steps were used to improve the validity of retrospective reports and to ensure that we obtained accurate data regarding how the innovation projects evolved over time (Miller et al., 1997). By following these steps, we were able to obtain a unique level of detail regarding the evolution of the projects

Table 2
Number of key data sources and interviews for each case.

Case	Secondary sources		Interviews				Total number of interviews
	Project description	Final reports	Project manager	Firm researcher	University project manager ^a	University researcher	
1	1	1	1	1			2
2	1	1	1				1
3	1	1	1			1	2
4	1	1	1	1	1	1(p)	4
5	1	1	1	1			2
6	1	1	1				1
7	1	1	1	1		1(p)	3
8	1	1	1(p)	1	1		4
9	1	1	1		1	1	3
10	1	1	1	1		1	3
11	1	1	1	2	1		4
12	1	1	1	1	1		3
13	1	1	1		1		2
14	na	Na	1				1
15	1	1	1(p)	3(p)	1(p)		5
sum	14	14	15	12	7	6	40

na = not available, (p) = phone interview.

^a The informant was a university researcher with a formal role as the manager of the university portion of the project.

that ex post were deemed successful.

3.4. Data analysis

Our data provided both narrative accounts of the process (Pentland, 1999) and factual descriptions of the context, actors, and events from different sources. The first step in analyzing the data was to write narrative case descriptions of each case based on triangulation of the interviews and available documents. These case descriptions were verified by each firm's project manager and were discussed with contact persons at the government support program as a validity check (Miller et al., 1997). In this manner, we were able to reconcile views from different sources and provide a thorough understanding of how the process unfolded over time, from initiation of the innovation project to its ex post outcomes.

Our analysis followed an extended case study approach aimed at integrating and extending existing theory. This approach entails the examination of literature relevant to the problem area and the use of empirical data to fill in gaps, reveal flaws, elaborate on meaning, and extend coverage (Burawoy, 1998; Danneels, 2002). To develop theoretical explanations for the processes observed, we identified observations that matched the theoretical concepts (Orton, 1997). To avoid conflating multiple levels of analysis, a retroduction strategy was used (Downward and Mearman, 2007; Leca and Naccache, 2006). Hence, we chose not to quantify the data through grounded theory-style coding because this technique could conflate the different levels of interaction, as well as the timing of events throughout the collaborative project. Instead, we adopted an abductive approach, in which empirical observations were used to refine our theoretical understanding regarding how the collaboration projects evolved over time; this approach allowed us to maintain the indivisible connectedness of elements (Wadham and Warren, 2014). Thus, as the analysis proceeded, the overarching logical frame shifted from exploring the data to building theoretical models and empirically scrutinizing these models (Van de Ven and Poole, 2002). This approach is similar to the systematic combining process of Dubois and Gadde (2002); specifically, we aimed to cross-fertilize insights from the social capital literature with in-depth empirical data. Hence, our approach is inspired by the structuralist approach to social capital (Kilduff and Tsai, 2003; Lounsbury and Ventresca, 2003) and thereby endeavors to capture the broader context and processes of university-industry collaborations, rather than their attributes.

The data analysis entails the triangulation of data sources to analyze each case, followed by a cross-case comparison to obtain a comprehensive picture of how the project and firm levels interact with external collaboration partners, such as university researchers. Each project was coded for key dimensions of social capital. The operationalization of social capital construction is elaborated below, and the coding is shown in Table 3. Table 4 presents additional evidence, including quotes from the interviews.

4. Findings and discussion

4.1. The role of social Capital dimensions in university-industry collaboration

All the innovation projects in our study involved collaboration between a firm and at least one university partner, and all the case firms described the university partners as important to the outcome of the project, usually referring to the specific university researchers involved in the project. As our analysis progressed, we observed that the firms used different paths to build the social capital necessary for successful collaboration over time, depending on their general experience in collaborating with university researchers and their academic expertise at project start. As a basis for the analysis, we mapped the case firms' cognitive and relational social capital at the outset of the projects, as

shown in Table 3.

Table 4 summarizes the core dimensions of cognitive and relational social capital and provides illustrative quotes related to the two groups of firms mapped in Table 3. In the following sections, we examine the role of cognitive and relational social capital at the project start and the interplay among these social capital dimensions over time, and we develop propositions regarding university-industry research collaboration.

4.1.1. Cognitive dimension of collaborations between firms and universities

Cognitive social capital can take the form of shared interpretations and systems of meanings (Cicourel, 1974), common languages and codes (Monteverde, 1995), and shared narratives (Orr, 1990) among parties. Cognitive social capital is therefore examined in terms of the firm's collaborative experience in general, in which we map previous collaborations with different university partners at project start and in terms of the firms' academic expertise (e.g., employed PhDs). We assert that this provides an indication of the firm's ability to communicate and share academic knowledge (Wasko and Faraj, 2005). Accordingly, when analyzing the case firms, we distinguish between high, moderate and low levels of cognitive social capital.

As shown in Table 3, firms with high levels of academic expertise and prior collaborative experience with different universities are characterized by higher levels of cognitive social capital (cases 1–7). These firms appear to be highly conscious of the value of having shared goals with the collaborating university researchers, and they emphasize the importance of common understanding. As one firm representative stated, *"It is very important that we [the firm] and our collaborative research partners are clear about our goals and wishes. In addition, [it is important] that we make space for the involved research collaborators – to make room for creating something new. The combination of shared goals and space for the creation of newness is very important."* Firms with higher levels of cognitive social capital have the expertise necessary to understand the type of complementary competence they need and to identify relevant knowledge sources. This expertise is illustrated by one firm's research manager: *"It is a strategic choice regarding which research institutes you want to pursue and develop over time; these are the ones you choose."*

Moreover, firms with higher levels of cognitive social capital have common languages and codes (Monteverde, 1995) related to the technologies involved. These firms have employees with PhD degrees and possess knowledge similar to that of university researchers. These firms use innovation projects to add specialized knowledge from university researchers that is relevant to further technological development (Lane and Lubatkin, 1998). Several firms with higher levels of cognitive social capital emphasize that their communication with collaborative university researchers is strong and that the firms and the university researchers share a similar culture (Inkpen and Tsang, 2005). For instance, certain projects include integrated teams of university researchers and company employees, which was noted by a university researcher as follows: *"It has become a [university-firm], what I call a virtual research group. A very good network. We know each other very well."*

In contrast, we found that firms with limited academic expertise and collaborative experience with a more narrow set of university researchers are characterized by lower levels of cognitive social capital (cases 8–15). These firms find it more challenging to collaborate with university researchers because they lack a common understanding, goal and culture. Several firms with lower levels of cognitive social capital appreciate the value of collaborating with university researchers, but they do not communicate effectively with them because the university researchers are too specialized and use a language that is difficult for the firms to understand. The differences in knowledge bases between these firms and the university researchers were described as challenging by several informants, such as this firm representative: *"My experience with academic groups is that they have a great deal of knowledge, but we are working with a relatively simple technology that is not directly*

Table 3
Case firms' levels of cognitive and relational social capital with university partners at the project start.

	Level of cognitive social capital	Level of relational social capital
Definition	General experience with university collaboration and academic expertise at project start.	Prior contacts and collaboration experience with the specific university researchers at project start.
1 Biotech	High level: Long-term experience with internal R&D, which is a key part of the firm's operations; several university collaborative projects before the current project.	Low level: No prior contacts with the university partners.
2 ICT	High level: The firm is a spin-off of the university partner in this project. R&D is the main activity of the firm. Both of the firm representatives were academic researchers.	Moderate level: Founders were previously employed by the university partner.
3 Large process industry	High level: Own R&D department; long-term experience with R&D through several prior projects. The main firm representatives hold PhDs.	High level: Company founder and university researcher were previous classmates or colleagues. Prior projects with the same university as the current project.
4 Large process industry	High level: Internal R&D team; long-term experience with R&D through several prior projects. The main firm representatives were former academic researchers.	High level: Prior relationship with the university partners; project leader at university partner was a former employee of the firm. Prior projects with the same university as the current project.
5 Science-based	High level: The firm is established by researchers. R&D is the main activity of the firm. The firm representatives have scientific backgrounds from universities and hold PhDs.	Moderate level: The company founder and university researcher were former classmates or colleagues.
6 Science-based	High level: The firm is a spin-off from a research institute. Prior collaborative projects with other partners; R&D is a key part of the firm's operations. Firm representatives work as scientists.	Moderate level: No prior relationship with the primary university partner; founders were previously employed by the other university partner.
7 Biotech	High level: Previously participated in a small R&D project that was a trigger for the current project; R&D is the main activity of the firm. Close contacts with academic researchers, and firm representatives were former academic researchers.	Moderate level: One of the firm's founders had a good relationship with the university partner.
8 Engineering	Moderate level: Prior collaborative projects with the same university and with other university partners; experience from similar projects; own R&D department; the firm representatives hold master's degrees.	High level: Prior relationships with all university partners. Prior projects with the same university as the current project.
9 Large process industry	Moderate level: The firm's R&D department ran two preliminary projects before the current project, and the firm has its own R&D department. Firm representatives have engineering competence.	High level: All the universities, except international universities, were known partners from prior projects.
10 Network, several firms	Moderate level: Project initiated by public research institute; prior university collaborative projects with a few other universities; firm representatives have engineering competence.	High level: Prior working relationships among several of the project partners. Prior projects with the same university as the current project.
11 Engineering	Moderate level: Ongoing R&D activity; firm representatives have engineering competence.	High level: University partners were all well acquainted through prior collaborations. Prior projects with the same university as the current project.
12 Engineering	Moderate level: Prior university collaborative projects with a few other universities; R&D is important in building the firm. Firm representatives have engineering competence.	High level: Prior collaboration with a key researcher at the university. Prior projects with the same university as the current project.
13 Engineering	Low level: The firm participated in previous product development projects, but the current project was the firm's first R&D project. Internal R&D and strong intentions to increase R&D activity; firm representatives have engineering competence.	High level: The firm project manager was previously employed by the university partner.
14 Engineering	Low level: The firm's R&D department ran two preliminary projects before the current project. Firm representatives have engineering competence.	High level: The firm project manager was involved in prior research at the university.
15 Process industry	Low level: No university collaborative projects before the current project, but R&D is important in building the firm; firm representatives have engineering competence.	Low level: University partners were unfamiliar with the firm.

transferable to the latest developments at the research frontier." In several cases, firms with lower levels of cognitive social capital were reluctant to interact closely with university researchers and therefore maintained a distance. This practice may result in frustration, as observed by one firm representative: "[The university researcher] was always frustrated and wanted to be closer to us. We kept him at a distance because confidentiality is always a consideration."

Although firms with lower levels of cognitive social capital find it challenging to collaborate with university researchers in general, they collaborated well with the university partners in the innovation projects examined by this study.

4.1.2. Relational dimensions of collaborations between firms and universities

The construct of relational social capital is operationalized through the dimension of reciprocity. Reciprocity is an aspect of trust; it is considered a key aspect of relational social capital that facilitates collaborative action (Coleman, 1990; Cooke et al., 2005) and refers to the expectation that individuals' collective actions will be reciprocated (Putnam, 1995). In general, trust develops through favorable past

interactions among parties (Wasko and Faraj, 2005). While cognitive social capital was mapped through the firms' levels of *general* experience of collaborating with universities at projects start and their academic expertise (e.g., employees with a PhD degree), relational social capital is measured by reciprocity in the form of prior contacts and collaboration experience between the *specific* researchers at project start.

The mapping of relational social capital did not reveal any clear patterns that differentiated between the firms with higher and lower levels of cognitive social capital; close relationships are generally important for successful collaborations with research partners. Depending on the level of cognitive social capital, however, firms take advantage of the relational social capital during different phases of the project, which was important for the exchange of information (Uzzi, 1999) and for succeeding in the collaboration over time. Firms with lower levels of cognitive social capital relied more extensively on relational social capital when establishing contacts with university partners, based on their pre-existing acquaintances with academic researchers. Hence, these firms substituted the lack of cognitive social capital by using relational social capital typically based on contacts with specific university

Table 4
Illustrative quotes related to the case firms' level of cognitive and relational social capital with university partners at project start, as mapped in Table 3.

	Cases 1-7	Cases 8-15
Cognitive social capital	High levels of cognitive social capital; significant general collaboration experience with universities and academic expertise at project start.	Low levels of cognitive social capital; limited general collaboration experience with universities at project start and lower academic expertise.
Illustrative quotes related to general experience with university collaboration	<p>"We collaborated with several international universities." (Firm partner, Case 1)</p> <p>"We have collaborated with international universities." (Firm partner, Case 3)</p> <p>"We have collaborated with national and international universities." (Firm partner, Case 4)</p> <p>"We have achieved several projects financed by the Research Council of Norway before." (Firm partner, Case 5)</p>	<p>"We had no experience with R&D-collaboration at that time. The most R&D-related we did was this project." (Firm partner, Case 15)</p> <p>"We got experiences by working like this [talking about the current project which was the first research project the firm was involved in]." (Firm partner, Case 13)</p>
Illustrative quotes related to academic expertise	<p>"I have learned the research language." (Firm partner, Case 5)</p> <p>"We had the scientist on one side and the industrial team on the other side communicating at a good level." (Research partner, Case 4)</p> <p>"It is not easy in day-to-day life to read heavy scientific articles you don't understand, but after working with someone for a few years, you really understand more." (Firm representative, Case 6)</p> <p>"We had a previous project with a PhD student who got to know the company well. He is now a post doc and contributed a lot to this project." (Firm partner, Case 7)</p>	<p>"In collaboration with universities, we often experience that the focus is directed toward their desires. They [the university] want to get more research contracts, but we are interested in finishing the project when the technology is ready." (Firm partner, Case 14)</p> <p>"The competent people on each side of the table had very good relationships with each other, whereas the less competent people did not get along well." (Firm partner, Case 15)</p> <p>"Many specialized partners are too specialized, which makes it difficult for us to understand." (Firm partner, Case 15)</p> <p>"It is important for us academics to be aware that the industry operates under different conditions than we do. It is also important that the industry understands our way of working." (Research partner, Case 11)</p>
Illustrative quotes related to relational social capital	<p>"We know each other very well. [The firm] has been very open with us about issues that for them are very confidential. We have been willing to operate with the same degree of confidentiality as [the firm] itself, so it can have complete trust in us." (Research partner, Case 4)</p> <p>"I graduated from [University X] and know many people from that time." (Firm partner, Case 3)</p> <p>"There were many of the same professors, too. [Person X], my boss at that time, had several contacts [in the research environment] that we used." (Firm partner, Case 5)</p> <p>"I went to the same university as [researcher X]." (Firm partner, Case 5)</p>	<p>"I was employed there [the university] for four years." (Firm partner, Case 10)</p> <p>"He [the project manager] had a good relationship with [university researcher X]...and they were willing to participate in the project." (Research partner, Case 12)</p> <p>"When the project was established, there were good prior relations with all of the partners." (Firm partner, Case 8)</p> <p>"We had a previous collaboration with them [one of the research institutes]." (Firm partner, Case 9)</p> <p>"When it came to R&D partners, it was natural to choose partners with which we had worked previously." (Firm partner, Case 14)</p>

researchers when entering the collaboration. As stated by a research partner collaborating with a firm with lower levels of cognitive social capital, "It was acquaintances who started talking about the technology as a possibility." Successful collaborations rely heavily on the individual researchers' willingness to initiate relationships with firm partners (Boehm and Hogan, 2014; Goel et al., 2017).

Relational social capital was not critical for the firms with higher levels of cognitive social capital (cases 1–7) when establishing their university collaborations. Nonetheless, the collaboration was strengthened through relational social capital over time, which was important to the collaborative success. One such firm had low levels of relational social capital with their university partners at the project launch (case 1). This firm approached collaborative partners based on the type of knowledge they needed, rather than prior relationships with specific university researchers. The remaining six firms in this category had prior relationships with several of the core university researchers in the current project. All the firms with high levels of cognitive social capital developed relational social capital towards collaborative university researchers, however, which was important for success in the projects over time, as expressed by a firm representative: "Our strength is the good relationships between academics and the developers."

Although many firm representatives claimed that they had no previous collaborative experience with their respective research partners, strong personal connections among the collaborative partners often existed through prior contact. As explained by a representative of a firm with a higher level of cognitive social capital, "I had been working [at the university partner] for a long time. I knew the system very well." Within both groups of firms, many representatives emphasized the ease of working with known partners.

One main difference between the two groups of firms, however, lies in the awareness of the value of personal relationships. Generally, firms

with higher levels of cognitive social capital were more strategic about the involvement of external partners in their innovation projects. Several firms with higher levels of cognitive social capital purposefully invested in building relevant competence at collaborative universities, which generated very close relationships between the firms and the respective university researchers, as explained by a university researcher: "I have more and closer contact with them (firm employees) than I have with many colleagues here [research institute]." Another university researcher explained why the firm had chosen the university as a long-term collaboration partner: "It is because [the firm] sees it as knowledge building for us [the university]. When we then eventually build on that specific competence, we are very useful for [the firm] and can go directly into production and solve the problems as well as their own researchers can." In contrast, firms with lower levels of cognitive social capital select partners among university researchers with whom they are familiar based on personal relationships.

Trust is also important when firms select collaborative partners because it reduces opportunistic behavior (Putnam, 1993) and causes an actor to be more willing to share resources (Li et al., 2013; Tsai, 2000). We observed collaborations characterized by high levels of openness and interaction between the firms and their university partners, which we believe is a result of the confidentiality and trust developed between the firms and university researchers over time (Ferriani et al., 2009). Several university researchers are highly conscious of the value of trust. A university employee that collaborated with a firm with lower levels of cognitive social capital made the following statement: "If we end up doing something that breaks the trust-based relationship, such as slipping with confidentiality, it can destroy the collaboration very quickly". Moreover, firms with lower levels of cognitive social capital strengthen the relational social capital towards the university researchers through frequent interactions (Wasko and Faraj,

2005) during the current project as the following quote illustrate: “We had regular meetings with presentations, both face to face and via telephone.”

It seems clear that relational social capital is crucial to innovation-oriented tasks (Moran, 2005); however, relational social capital may be the dimension of social capital that requires the longest time and greatest commitment to develop. For firms with the highest levels of relational social capital, this capital is rooted in old acquaintances, such as classmates and former colleagues. One university researcher collaborating with a firm with higher levels of cognitive social capital described the role of trust as follows: “We have shown that we are able to protect [the firm’s] confidentiality, and [the firm] invests in our knowledge building.” He also explained the time-consuming process of trust building as follows: “It takes a long time for [the firm] to involve other research partners because you have to show that you protect confidentiality.”

The absorptive capacity concept implies that high dissimilarity between partners facilitates the creation of novel innovations, but it also gives rise to associated difficulties in communication (Cohen and Levinthal, 1990). Our cases suggest that a high level of relational social capital between the firm and its university partner can counteract the negative effects of dissimilarity between them (i.e., low cognitive social capital). Relational social capital is important for all firms, but it appears to be particularly important for firms with less experience with university collaboration at the project start. These firms compensate for their lack of cognitive social capital by relying on relational social capital when they establish collaborations with university researchers for innovation projects. Thus, we propose:

Proposition 1. Firms with lower levels of cognitive social capital with university researchers are more likely to establish their university collaborations on the basis of relational social capital than are firms that have higher levels of cognitive social capital with university researchers.

4.2. The interplay of social capital dimensions over time

We now examine the interplay of cognitive and relational social capital dimensions over time, which has rarely been addressed in empirical studies (Lee, 2009; Payne et al., 2011; Rass et al., 2013). Our findings and propositions are summarized in Table 5 and Fig. 1, which provide a dynamic model of the interplay and evolution of social capital dimensions in the context of university-industry collaboration. The arrows in Fig. 1 represent the process of building social capital in university-industry collaboration that emerges from this study. Specifically, the circles illustrate how social relationships develop over time from a project’s beginning to its successful outcome, depending on the firm’s level of prior collaboration experience with university researchers and academic expertise.

Table 5
The interplay and evolution of cognitive and relational social capital dimensions in university-industry collaboration.

	Firms with higher levels of cognitive social capital (cases 1-7)	Firms with lower levels of cognitive social capital (cases 8-15)
Establishment of the collaboration	<ul style="list-style-type: none"> • Prior collaboration experience with the university researchers existed for several of these firms but was not critical for the establishment of the innovation project. • These firms appear to have sufficient expertise to recognize the type of complementary expertise they need to develop innovations. 	<ul style="list-style-type: none"> • Prior collaboration experience with the university researchers was important for the establishment of the current project. • Typically based on relationships with specific individuals within the universities who were important to the establishment of the current projects (see Proposition 1).
Level of relationship	<ul style="list-style-type: none"> • Organizational relationships rather than individual relationships. 	<ul style="list-style-type: none"> • Individual relationships rather than organizational relationships.
Interplay over time	<p>These firms displayed significant development in the level of relational social capital among the individuals working on the project, which was essential to collaborative success over time (see Proposition 2). Varying levels of interaction with the university researchers during the current project.</p>	<p>Through their initial relational social capital, these firms were able to reinforce their cognitive social capital and thereby increase their general ability to engage successfully with university researchers over time (see Proposition 3). Frequent interaction with the university researchers during the current project^a.</p>

^a Except case firm 15.

Despite lower levels of prior collaboration experience with university researchers and academic expertise (i.e., cognitive social capital) when commencing the innovation projects, these firms (cases 8–15) managed to successfully collaborate with university researchers over time. It appears that this group of firms is highly dependent on relational social capital with the specific university researchers in the current project, which compensates for the lack of cognitive social capital at the beginning of the collaboration. These collaborations often constitute the firms’ main R&D activities and knowledge-building efforts.

We confirm the findings of Ashforth and Mael (1996) that an interdependency exists between shared language and social relationships and that shared understanding leads to effective social interaction (Reveley et al., 2004). Specifically, we observed that by interacting closely with university researchers during the project (Wasko and Faraj, 2005), firms with lower levels of cognitive social capital at the outset of their collaborations were able to reinforce their cognitive social capital and thereby increase their general ability to engage successfully with university researchers. Accordingly, relational social capital compensates for the lack of experience in collaborating with university researchers and academic expertise (cognitive social capital) at the beginning of the collaboration. As stated by a representative of a less experienced firm, “[This project] created a basis for the firm to invest fairly heavily in R&D. From having a small workshop with a guy who was kind of a ‘medicine man’, [...] it has become a firm competence. When we replace people, it runs fairly smoothly [...] Yes, the experiences from [this project] allowed us to see that it was useful to maintain contact and to work with research. We are building a more research-oriented organization [...] and are connecting more closely to [another university].”

Additionally, the configuration of firms’ social capital across different individuals creates a more differentiated and complementary composition of social capital at the firm level (Maurer and Ebers, 2006). Our cases show that specific employees of these firms are particularly important for the accumulation of cognitive social capital, and they often play the role of “research translators.” This finding is particularly true for firms with lower levels of cognitive social capital because the collaboration projects relied more on specific individuals. For example, in one case, a firm employee was previously employed by the firm’s university partner. This employee enabled the firm to develop cognitive social capital among other employees in the firm. Essentially, firm employees initiated the collaboration with university researchers, and additional partners were chosen based on their relevant expertise. This finding is in accordance with Zaheer et al. (2000), who argued that shared visions arise through interaction among organizations.

Due to limited experience with university collaboration and academic expertise, firms with lower levels of cognitive social capital at the beginning of the collaboration require more time to reinforce this dimension of social capital because they must develop a mutual understanding and language with their collaborative university researchers

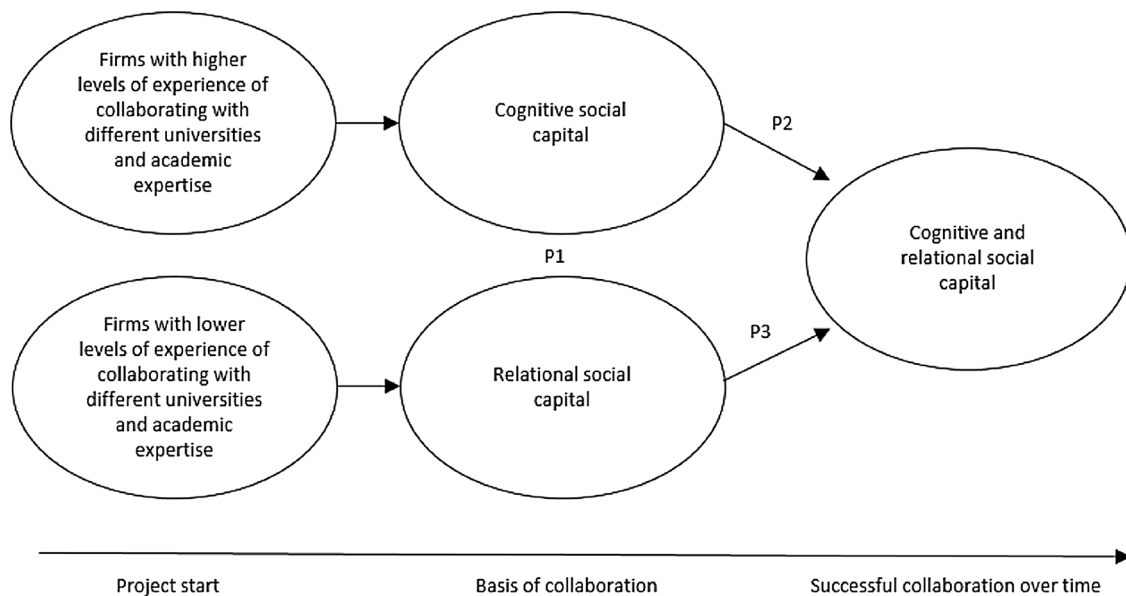


Fig. 1. The interplay and evolution of cognitive and relational social capital dimensions in university-industry collaboration.

over time. The presence of trust and mutual respect through prior contact (i.e., relational social capital) with their initial collaborative university researchers helps these firms accumulate the cognitive social capital necessary to reach common understandings, develop shared goals, and establish collaborations with other universities. This quote from a relatively small firm illustrates how it integrated its internal R&D activity with its university partner: “We have had a key person at [the research institute] who has followed us since 1994, I think. He is still there and is often used in new projects. He has been very good for [the firm]. The reason for [this collaboration] is that we thought that if we [hired a researcher at the firm] [...], he would fade as a researcher. Thus, it is better to have him situated and mingling in a research group.”

Firms with higher levels of cognitive social capital (cases 1–7) were better able to understand their university partners and to benefit from their collaborations. Moreover, these firms displayed significant development in the levels of relational social capital among the individuals working on the projects, which was essential to collaborative success over time. As explained by one university researcher, “[the project] ran for several years, allowing us to build competence and equipment and, more importantly, to maintain a close and strong collaboration with the industry, not only writing reports but also sitting at the same table to discuss solutions and ideas and interpret results ... with all of us having steep learning curves. Thus, I think affinity among the people involved plays a role. I think the affinity was very good. Personal affinity is important, especially when working together over many years.” Accordingly, firms with strong prior collaborative experience and academic expertise are likely to experience a reinforcing interplay of cognitive and relational capital over time.

In summary, we find that both cognitive social capital and relational social capital are important for firms to successfully manage university collaborations over time. Firms with various levels of initial cognitive social capital, however, follow different paths to develop this combination. Thus, we propose the following:

Proposition 2. Firms that initially establish their university collaboration on the basis of cognitive social capital are more likely to benefit from the collaboration if it is reinforced by relational social capital over time.

Proposition 3. Firms that initially establish their university collaboration on the basis of relational social capital are more likely to benefit from the collaboration if it is reinforced by cognitive social capital over time.

5. Conclusions and implications

This paper refines our understanding of how social capital facilitates collaboration between firms and university researchers in the development of innovations. By studying 15 successful innovation projects, we developed propositions that outline how firms with higher and lower general levels of cognitive social capital with university researchers manage to collaborate effectively in innovation projects with specific university researchers over time. Our study shows that both the cognitive and relational dimensions of social capital are important for successful collaboration. However, our key contributions are linked to the manner in which these social capital dimensions interact and develop over time based on the firm’s initial level of cognitive social capital generated by prior experience with university collaborations and academic expertise. Hence, our findings add to the previous research, which shows that the pattern of cognitive and relational social capital changes over time (Al-Tabbaa and Ankras, 2016; Hughes and Perrons, 2011).

Firms with higher levels of prior collaboration experience with several university researchers and academic expertise are found to rely on cognitive social capital when entering innovation projects. The importance of the relational dimension for innovation-oriented tasks (Moran, 2005) is further emphasized by our observation that firms with higher levels of cognitive social capital tend to reinforce their cognitive social capital by developing relational social capital during the course of the collaborative projects. The most notable finding, however, relates to how firms with lower levels of prior experience with university collaboration and academic expertise (i.e., lower cognitive social capital) can collaborate successfully with university researchers. These firms typically rely on individual relationships when establishing collaborations. Hence, relational social capital compensates for a lower level of cognitive social capital when establishing collaborations. Thus, in accordance with previous findings, relational social capital appears to be the most important dimension of social capital for these firms in terms of inter-organizational learning and innovation (Van Wijk et al., 2008); however, these firms reinforce relationships with university partners by building cognitive social capital over time.

By adopting a social capital perspective, our study provides several new insights regarding the micro foundations of university-industry collaboration, and it contributes more generally to the scant amount of research on how inter-organizational relations come into being and how they function (Berthod et al., 2016). Although individual-level

intra-firm social capital has been found to promote innovation (Tsai and Ghoshal, 1998), we observe how social capital develops across organizational boundaries to facilitate successful innovation projects. In this case, the significant differences in culture and orientation between industry and academia necessitate high levels of social capital to overcome barriers to collaboration (Bruneel et al., 2010).

The development and maintenance of social capital is costly and resource intensive (Maurer and Ebers, 2006; Nahapiet and Ghoshal, 1998). Our study demonstrates how firms with limited levels of cognitive social capital can build effective social relationships based on relational social capital. Although reliance on relational social capital has disadvantages stemming from the limited set of available collaboration partners, it may be a cost-efficient solution for smaller firms with limited resources to develop cognitive social capital with university researchers. Thus, firms with less collaborative experience with universities and academic expertise may be able to collaborate and create innovations in collaboration with university researchers through relational social capital. To maintain and improve their innovative performance, however, these firms would benefit from the development of stronger firm-level connections with universities through enhanced cognitive social capital. Furthermore, by transferring individuals' relationships to an organizational level, firms can reinforce their organizational cognitive social capital and thereby strengthen their research collaborations.

5.1. Implications for practice

To capitalize on their existing relationships and create efficient new relationships, firms must understand how to manage and organize their social relationships. Firms with higher levels of cognitive social capital with universities typically possess absorptive capacity and may benefit more from such collaborations in terms of innovative performance. These firms can use their firm-level cognitive social capital to establish relationships with relevant university partners. In rendering these collaborations successful, however, it appears to be important to reinforce the relationship between the firm and university researchers by ensuring that individuals across the organizations develop relational social capital.

Our study suggests that firms with lower levels of cognitive social capital must organize their social relationships with universities differently. These firms may compensate for their low levels of cognitive social capital by relying on relational social capital. Hence, firms with lower levels of cognitive social capital are more limited in their choice of collaborative partners. Nevertheless, these firms may be able to establish collaborations that are equally as successful as those of their more experienced counterparts. Moreover, firms with lower levels of cognitive social capital can use their university collaborations based on relational social capital to develop stronger cognitive social capital over time. For policy makers, this finding indicates that research collaborations should not be evaluated solely in terms of their direct contributions to firm profits. Rather, the development of the firms' absorptive capacity, which may form the basis for future collaborations, must also be considered. This study demonstrated that starting with individual relationships may be a pathway to the development of cognitive social capital at the firm level.

5.2. Limitations and implications for further research

The findings regarding the interplay and evolution of social capital may be specific to innovation projects with universities. Collaboration for the purpose of innovation development appears to involve fewer tangible resources and more tacit knowledge than does collaboration for other purposes. Hence, relational social capital based on trust and personal support may be particularly important (Moran, 2005) for collaboration to develop innovations; thus, our findings may not be directly transferable to inter-firm collaboration for other purposes.

The number of cases in this study was higher than that which is often recommended for theory-developing case studies (Eisenhardt, 1989). This choice was driven by the excellent availability of historical documentation regarding collaborative projects; however, the retrospective data in this study have limitations in terms of providing precise measures of social capital dimensions. Future studies should perform more detailed investigations of selected collaborations, preferably by collecting data in real time to more closely represent the actual events. Clearly, there is a need to better understand the social capital mechanisms underlying inter-organizational collaboration and the dynamics of these mechanisms over time. Relying exclusively on qualitative studies of social capital may be overly descriptive, however, which suggests the need for mixed methods to obtain a more comprehensive understanding of how networks are generated and of the process linkages among different social capital dimensions (Lee, 2009).

We observed that the innovation projects in our case investigations were typically highly interrelated with other preceding or succeeding innovation projects, often with similar collaboration partners. Although using the project as the unit of analysis brought us closer to the performance of the actual collaborations, both qualitative and quantitative research on projects must consider the interrelated nature of innovation projects, which makes them difficult to analyze independent of the individual and firm levels.

The empirical setting—innovation projects receiving government grants—was highly useful in identifying relevant cases and enabling suitable access to data; however, the presence of grant funding may influence firm behavior. In our case, it seems clear that the firms had more extensive collaborations with universities because of the grants. This context was suitable for our purpose, to study how firms collaborated with universities, because we could access a number of cases in which firms with limited experience with university collaboration (i.e., low cognitive social capital) entered into such collaborations. Hence, we believe that the theoretical mechanisms identified in this study regarding how the collaborations unfolded are not significantly influenced by the existence of government grants. Whether and how firms with limited collaboration experience would initially engage with universities independent of such support, however, warrants further study.

A further limitation is that our study includes only ex post successful cases of innovation projects. Although our objective was to unravel the mechanisms underlying successful collaborations rather than to predict successful collaborations, further research is warranted to explore the differences among projects with different outcomes.

Finally, we observed that over time, several firms developed very open relationships with selected universities and that these relationships were characterized by very close interactions. In these cases, the organizational boundaries were highly ambiguous during the studied innovation processes. This manner of opening the firm's borders during the innovation process was clearly dependent on a high level of social capital, and it warrants further study.

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