Leena Kunttu

Learning practices in long-term university-industry relationships

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Julkaisun nimike
Oppimisen käytännöt pitkäaikaisissa yliopistojen ja yritysten välisissä yhteistyösuhteissa

Tiivistelmä
Tämä väitöskirja analysoi suhdeoppimisen käytäntöjä yliopistojen ja yritysten välisissä yhteistyösuhteissa. Väitöskirjan tulokset on esitetty neljässä artikkelissa, jotka tutkivat yhteisen oppimisen ja tiedon luomisen näkökulmia yritys-yliopistosuhteissa. Pääasiallinen tutkimusmenetelmä kaikissa artikkeleissa on haastatteluihin perustuva laadullinen tapaustutkimus. Väitöskirjan teoreettinen viitekehys perustuu suhdeoppimisen teorioihin. Tapaustutkimusten tuloksena esitetään joukko yhteistä oppimista yritys-yliopistosuhteissa edistäviä käytäntöjä. Toisena keskeisenä tuloksena työ esittää käytäntöjä, joiden avulla osapuolet voivat päästä yli yhteistyötä haittaavista organisatorisista esteistä. Työn teoreettinen kontribuutio sijoittuu yritys-yliopistoyhteistyön, suhdeoppimisen sekä oppimisen käytäntöjen tutkimusalueille.

Työn tulokset osoittavat, että henkilötason luottamus, osapuolten sopeutuminen toistensa prosesseihin sekä pyrkimys yhteisymmärrykseen yhteisten tutkimustulosten hyödyntämisessä ovat keskeisiä prosesseja, joilla osapuolet voivat alentaa yhteistyön esteitä. Tuloksissa nousee myös esiin suhteen yhteyshenkilöiden keskeinen rooli sillan rakentajina osapuolten välille. Väitöskirjan keskeisenä havaintona tuodaan esiin joukko yhteistyön käytäntöjä, joiden avulla yliopistojen ja yritysten edustajat voivat sitoutua pitkäaikaiseen yhteistyösuhteeseen ja edistää yhteistä oppimista ja uuden tiedon luomista tässä suhteessa.

Asiasanat
Yritys-yliopistosuhteet, suhdeoppiminen, oppimisen käytännöt

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Abstract
This dissertation analyzes the practices of relationship learning in university-industry relationships (UIRs). The empirical work is based on four articles, each presenting qualitative comparative case studies of collaborative relationships between industrial companies and academic research institutions in Finland. The case studies analyze the learning and joint knowledge creation, taking place in UIRs from different viewpoints. As a result of the case studies, the dissertation presents a variety of collaborative practices and mechanisms that facilitate learning in UIRs. As another main result, the dissertation suggests practices that help the UIR partners to overcome organizational barriers of university-industry collaboration. In this manner, the dissertation contributes to the literature on UIR collaboration, relationship learning in UIR context, as well as learning practices.

The findings of the dissertation reveal that the building of relational trust on personal level, adaptation to the partner's processes, and seeking consensus on the utilization of the jointly achieved research results are the main processes, which help partners to lower the barriers of the collaboration. The results highlight the role of boundary actors as facilitators of the relationship learning process. In addition, the results of the study also highlight several relational practices, which are able to help both academics and industrial actors to engage in a long-term collaboration, and enable successful relationship learning and knowledge creation and in their collaborative relationships.

Keywords
University-industry relationships, relationship learning, practices

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This year, we are celebrating the 500th anniversary of Leonardo da Vinci's death. Da Vinci is widely considered as one of the greatest polymaths in human history. He was an inventor, artist, musician, architect, engineer, anatomist, botanist, geologist, historian and cartographer. His true genius was not just as a scientist or artist, but a combination of these areas since he was expressing science through art. Now, 500 years after da Vinci's death, I am completing my second doctoral dissertation. This process has taught me how inspiring it is to combine different areas of science. During this dissertation work, I have been able to combine my previous understanding of engineering with new areas, such as management, economics and education.

This doctoral dissertation studies learning in the relationships between universities and industrial firms. This topic has been very close to me throughout my career, which involves working in both academic institutions and industry. During my work as Innovation Manager for the Nokia Corporation between 2007 and 2012, I was in charge of managing research-based relationships with universities. During this time, I realized the value of university-industry collaboration in developing new knowledge and innovations. I discovered that the meaning of knowledge is essential in this collaboration. Universities aim to create open and public knowledge, whereas companies wish to keep their knowledge a secret. Based on this, I identified my current topic of research: how to find practices for successful collaboration.

It has been a particular pleasure working with a number of experts representing both academia and industry. Firstly, I would like to thank Professor Yrjö Neuvo who has spared his time and valuable experience to mentor my work and co-write two articles for this dissertation. I am also grateful to my supervisor, Professor Josu Takala, who has advised me during the dissertation process. I wish to thank the University of Vaasa and especially Rector Jari Kuusisto for his positive attitude and invaluable support in my innovation research. I also wish to thank the School of Technology and Innovations for supporting my conference participation. My thanks also extend to Professor Antti Hautamäki for his support during the dissertation process.

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Special and enormous thanks go to my family. I am grateful to my beloved husband, Iivari, for supporting me in all areas of my life. I am a very happy mother of two adorable kids, Tähti and Otava, who give us joy, love and inspiration every day. I will love you forever.

May 2019

Leena Kunttu

The human foot is a
masterpiece of engineering
and a work of art.

- Leonardo da Vinci

Contents

Figures

Tables

Abbreviations

ICT	Information and communications technology
R&D	Research and development
UIR	University-industry relationship
UIC	University-industry collaboration

List of Articles

This dissertation is based on the following articles:

1. Kunttu, L., & Neuvo, Y. (2018). Balancing learning and knowledge protection in university-industry collaborations. *The Learning Organization,* 26(2), 190-204

2. Kunttu, L. (2017). Educational Involvement in Innovative University-Industry Collaboration. *Technology Innovation Management Review*, 7(12), 14–23.

3. Kunttu, L., Huttu, E., & Neuvo, Y. (2018). How Doctoral Students and Graduates Can Facilitate Boundary Spanning between Academia and Industry. *Technology Innovation Management Review*, 8(6), 48–55.

4. Kunttu, L., & Takala, J. (2019). Involving customers and users in university-industry collaboration. *Paper presented at the ISPIM 2019 Innovation Conference, Florence, June 2019.*

1 INTRODUCTION

1.1 Background

Following the principles of open innovation (Chesbrough, 2003; Enkel, Gassmann, & Chesbrough, 2009; West, Salter, Vanhaverbeke, & Chesbrough, 2014), industrial firms are increasingly extending their product development and innovation capabilities with external partners that may provide them with valuable competences, capabilities and knowledge. This is particularly true for firms operating in the rapidly developing knowledge-intensive technology industries, such as the information and communications technology (ICT) sector (Bellini, Piroli, & Pennacchio, 2018). According to the theories of learning organizations (Senge, 1993), there are a number of reasons for collaborating with external partners, including rapid technological changes; strong markets and competition; the complex nature of the innovation process with high levels of uncertainty; short product life-cycles; and the costs of internal product development (Bellini et al., 2018). Thus, the number of collaborative relationships between industrial firms and external partners has been steadily increasing during recent decades (Pennacchio, 2016).

Lately, a considerable amount of research interest has been focused on the interactions between industry and academic institutions. It has been widely accepted in previous research focusing on technology innovations "that the innovative capacity of a nation depends not only on the strength of individual players (firms, universities or government research laboratories) but perhaps more importantly on the links between these actors" (Morlacchi & Martin, 2009, p. 578). Thus, the relationship between science, technology and innovation is seen as interactive rather than linear, and the process of technological innovation should be considered a long-term evolution rather than a spontaneous creation of technologies and innovations. The meaning of inter-organizational interactions is highlighted as being a driving force for innovations in concepts of the "innovation system" (Pennacchio, 2016). For instance, close collaboration between universities and the business world has been seen as one of the strengths of the Finnish innovation system (Ormala, Tukiainen, & Mattila, 2014, p. 24). In some of these concepts (such as the triple-helix model of academic-industry-government relations), universities are assumed to have a leading role in the development of technological innovations and are seen as engines of growth (Etzkowitz & Leydesdorff, 2000). In this manner, collaborative relationships between industrial

firms and academic institutions are nowadays considered an important economic driver since they are expected to spur innovations and thus stimulate economic growth (Rajalo & Vadi, 2017; Weckowska, 2015). These benefits may be delivered through industrial utilization of the results of academic research. For this reason, governments are actively promoting the establishment and development of networks of universities and industrial companies by designing and implementing their national innovation policies (Morlacchi & Martin, 2009; Perkmann et al., 2013; Rajalo & Vadi, 2017). In this manner, the focus of policy-makers has moved towards the so-called "third mission of universities", which means that in addition to the fundamental tasks of education and academic research, universities are required to make societal contributions through collaborative knowledge creation, transfer and exchange (Pennacchio, 2016). Consequently, many universities have evolved from being a traditional academic institution characterized as an "ivory tower", to an "entrepreneurial university" interacting closely with industrial actors and taking an active role in knowledge and technology transfer (Pablo D'Este & Perkmann, 2011; Pennacchio, 2016).

Despite growing interaction between the academic world and industry, and the inevitable benefits for participating firms (Ankrah & AL-Tabbaa, 2015), partners in university-industry collaborations still have a rather limited ability to utilize the results of their joint efforts (Pennacchio, 2016). Moreover, academic research in collaboration with industry seldom translates into new inventions or products (P. D'Este & Patel, 2007). It has been shown that obstacles caused by different or contradictory objectives, organizational goals or cultural aspects among partners often limit the positive effects of university-industry collaborations (Bruneel, D'Este, & Salter, 2010; Galán-Muros & Plewa, 2016; Gomes, Hurmelinna, Amaral, & Blomqvist, 2005). A major root cause of these kinds of obstacles is the fact that the primary goal of universities is still to create open and public knowledge, and provide education, meaning that they prioritize academic objectives, such as long-term research, academic publications and degree courses for students (Lee, 2011). In contrast to this, industrial partners are private companies with a strong focus on capturing valuable knowledge that could facilitate competitive advantages in their business area through short-term research, which is directly associated with new product development and innovative functioning of the firm (Bruneel et al., 2010; Lee, 2011). To overcome the barriers caused by these fundamental differences, partners in university-industry relationships need to find ways of collaborating and managing their collaborative relationships (Clauss & Kesting, 2017). Thus, a common understanding in the previous literature is that organizational and managerial issues play a critical role in facilitating or inhibiting relationships between industrial actors and academia (Bellini et al., 2018;

Markman, Siegel, & Wright, 2008; Pennacchio, 2016; Siegel, Waldman, Atwater, & Link, 2004).

1.2 Research gap and contributions

Whereas the bulk of existing empirical work on university-industry relationships (UIRs) deals with knowledge transfer from academia to industry (Ankrah & AL-Tabbaa, 2015; see reviews in e.g. Perkmann et al., 2013), aspects of joint knowledge creation and learning in these relationships have received growing attention among scholars in recent years (Weckowska, 2015). However, as most of the existing research on relationship learning in a UIR context is quantitative in nature, concentrating on, for example, the determinants of innovation performance (Maietta, 2015; Pennacchio, 2016), barriers to collaboration (Bruneel et al., 2010), development of mutual trust (Bellini et al., 2018; Bstieler, Hemmert, & Barczak, 2017) or relationship governance (Clauss & Kesting, 2017), existing literature falls short in its qualitative analysis of the practices of relationship learning in university-industry collaborations. Thus, previous research provides minimal information about the practices of relationship learning processes occurring in research-based interactions between universities and industry. Indeed, Weckowska (2015) has studied learning mechanisms in technology transfer offices; Rajalo and Vadi (2017) have analyzed the collaborative behavior of UIR partners; and Estrada *et al.* (2016) have examined partner dissimilarities in this context. However, qualitative research on relational practices facilitating the UIR learning process remains absent. This is surprising for two reasons, firstly, because learning is an important process of organizational innovation, including knowledge acquisition and creation, interpretation and utilization (Fang, Fang, Chou, Yang, & Tsai, 2011; Kale, Singh, & Perlmutter, 2000); and, secondly, because the innovative performance of firms collaborating with universities depends on how successful they are at gaining knowledge and learning from these collaborative relationships (Bruneel et al., 2010; Laursen & Salter, 2004).

To fill this gap, this dissertation integrates three main research avenues: the literature concerned with research collaboration between universities and industry, the theory of relationship learning, and the theoretical concepts of learning practices (see Figure 1). This dissertation extends existing (mainly quantitative) UIR research by examining the relational-level practices related to the learning process between partners. The study also extends the existing UIR literature concerning organizational barriers to learning by presenting relational practices which may significantly lower these barriers to collaboration. In this manner, the dissertation makes two main contributions. The first contribution is

to extend the previous literature on university-industry collaboration by improving understanding of the facilitators of effective research collaboration in university-industry relationships (UIRs) and, importantly, overcoming the organizational barriers of collaboration. Secondly, the dissertation complements previous understanding of relationship learning in a UIR context by analyzing the practices of learning in collaborative relationships between academia and industry.

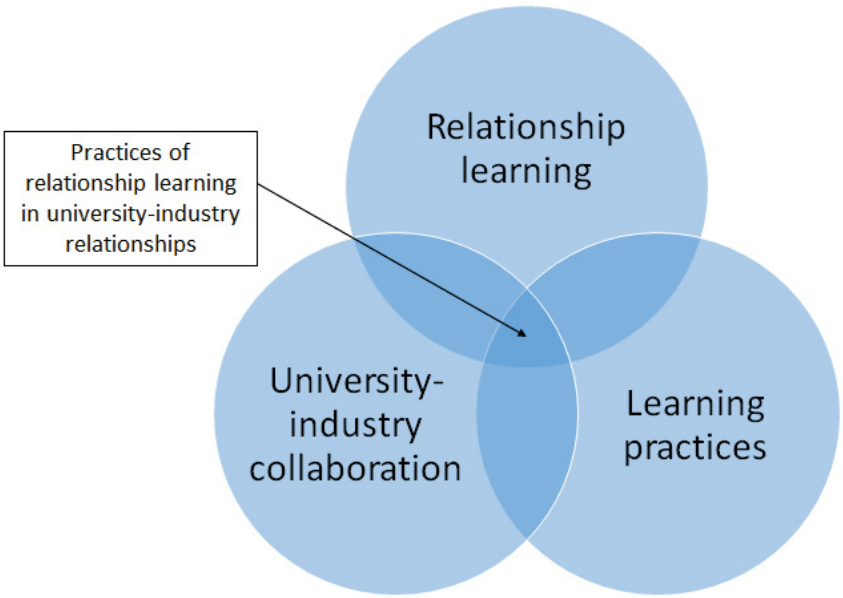

Figure 1. Research avenues in the dissertation

1.3 Research questions

This dissertation intends to improve understanding of the practices and mechanisms related to collaboration and learning in university-industry relationships by addressing the following research question:

RQ. What kinds of collaborative practices facilitate learning in long-term university-industry relationships?

This main research question is approached from different perspectives based on article-specific research questions:

Q1. What practices help industrial firms to achieve a balance between learning and knowledge protection in UIRs? (Article 1)

Q2. How can educational collaboration facilitate relational learning and knowledge creation in university-industry relationships? (Article 2)

Q3. How can jointly organized doctoral education programs facilitate the mobility of doctoral students and graduates from academia to industry? (Article 3)

Q4. How can customer and user involvement in UIR collaboration facilitate commercialization of the collaboration results? (Article 4)

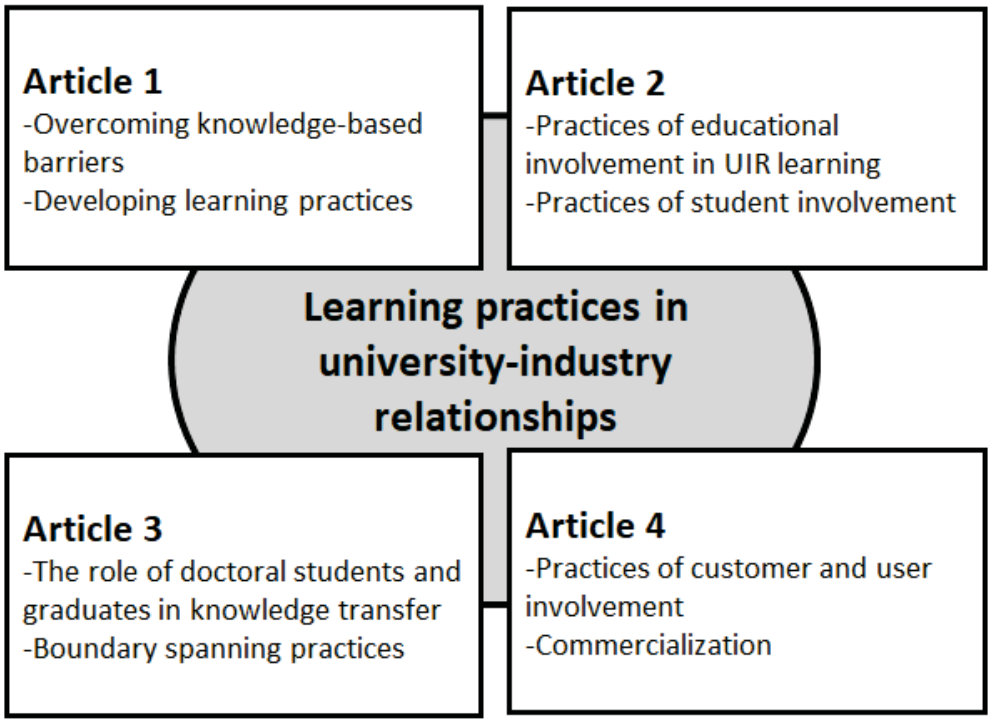

Figure 2. The framework of the dissertation

Figure 2 illustrates the role of the four articles, each associated with its own specific research question (Q1—Q4) in relation to the main goal of this dissertation. The first research question (Q1) is addressed in Article 1. This approaches the main goal of the dissertation by analyzing the tension between relationship learning and knowledge protection in UIRs. By means of a qualitative case study, Article 1 intends to identify relationship learning practices that help partners overcome knowledge-based barriers and develop facilitators for efficient learning in long-term UIRs. The second research question (Q2) in Article 2 focuses on educational involvement in long-term UIRs. The article examines the practices of educational

collaboration between academia and industry as part of UIR-based research collaboration. Educational aspects of UIR collaboration are also studied in Article 3, which aims to address the third research question (Q3). In Article 3, the focus is on the boundary actor role of doctoral students and graduates. The article analyzes how doctoral education jointly organized between academia and industry can facilitate boundary spanning between these two institutions. Finally, Article 4 addresses the fourth research question (Q4) by identifying the practices of customer and user involvement by means of a case study. Table 1 summarizes the key characteristics of the four articles.

1.4 Structure of the dissertation

The dissertation consists of two main parts. The first part contains five chapters, whereas the second part consists of four articles. The purpose of the first part is to provide the reader with an overview of the theoretical and conceptual framework on which this dissertation is built. The first part also presents the theoretical and practical contribution of the whole dissertation. Chapter 1 of the first part presents an introduction to the entire dissertation, including an overview, the gap in research, research questions and objectives. Chapter 2 introduces the theoretical framework that shapes the foundations of the dissertation. In Chapter 3, issues related to the research design and methodology are discussed, and chapter 4 gives a summary of each article. Chapter 5 presents the discussion and conclusions of the whole dissertation.

Table 1. A summary of the articles.

	Article 1	**Article 2**	**Article 3**	**Article 4**
Research focus	Examining the practices that help partners cope with tensions between learning and protection, and overcoming knowledge-based barriers in UIRs	Analyzing the practices and facilitators of educational involvement in UIRs	Investigating the role of doctoral students and graduates as academic boundary actors in UIRs	Analyzing the practices of customer involvement in the UIR commercializ-ation process

Theoretical concepts	Relationship learning in UIRs	Relationship learning in UIRs	Educational collaboration in UIRs	UIR commercialization and customer/user involvement
Research strategy	Comparative case study of six UIRs from the ICT industry in Finland	Comparative case study of nine UIRs from the ICT and technology industries in Finland	Comparative case study of three collaborative doctoral education programs in Finland	Comparative case study of five UIRs from the ICT and technology industries in Finland
Research context	Research collaboration between academia and industry	Educational aspects of research collaboration between academia and industry	Doctoral education programs jointly organized between academia and industry	Customer/user aspects of the commercialization of the outcomes of UIR collaboration
Unit of analysis	University-industry relationship	University-industry relationship	Doctoral education course	University-industry relationship
Data	Interviews and secondary sources	Interviews and secondary sources	Authors' experience, together with interviews and course feedback	Interviews and secondary sources
Main findings	Practices and processes that enable partners to overcome knowledge-based barriers to collaboration and facilitate efficient learning	Practices of educational involvement in UIRs as facilitators of UIR learning	Practices of collaborative doctoral education as facilitators of boundary spanning between academia and industry	Collaboration practices involving end users and customers, which facilitate the commercialization of university-industry collaboration

Practical implications	Practices supporting engagement in collaboration, and facilitating knowledge creation and utilization in UIRs	Practical aspects and collaboration forms, enabling industrial partners to engage with university education and involving students in the joint learning process	Industrial engagement in doctoral education, facilitating the mobility of young academics from academia and industry	Practices enabling UIR partners to involve the customers of their industrial partners in the commercializ-ation of joint knowledge creation and innovation

2 THEORETICAL BACKGROUND

2.1 University-industry collaboration

Industrial firms nowadays often invest remarkable amounts of resources, such as time and money, when seeking new innovative opportunities outside their boundaries, and they utilize many kinds of external relationship to help them achieve and sustain innovation (Cohen & Levinthal, 1990). This kind of exploration is based on the assumption that firms' innovative performance depends on how successful they are at appropriating knowledge from these sources (Cohen & Levinthal, 1990). Thus, investment in innovation collaboration with external partners can increase a firm's ability to create new knowledge and recombine new and existing knowledge (Laursen and Salter 2006). Laursen and Salter (2004) showed that the firms seeking opportunities to collaborate with external partners such as suppliers, customers, or even competitors may gain more from collaboration with academic institutions. In this manner, collaboration with academia is crucial for industrial actors, not only to utilize externally available knowledge resources (such as scientific research staff and research infrastructure) but also to absorb and utilize research-based scientific knowledge. This is particularly crucial in the knowledge-intensive industrial areas that are characterized by high uncertainty (Bellini et al., 2018). Thus, collaborative relationships between academia and industry do not only combine heterogeneous partners but also heterogeneous knowledge possessed by these partners (Estrada, Faems, Martin Cruz, & Perez Santana, 2016; Rajalo & Vadi, 2017). Industrial firms' interest in research-based collaboration with academia is based on the view that collaborative research between academia and industry can be a remarkable facilitator for innovation (Ankrah & AL-Tabbaa, 2015; Perkmann et al., 2013). University-industry collaboration (UIC) refers to the interaction between any parts of the higher education system and industry, aiming mainly to encourage knowledge and technology exchange (Ankrah & AL-Tabbaa, 2015; Bekkers & Bodas Freitas, 2008; Siegel et al., 2004). Thus, collaboration between universities and organizations acting within the private sector has been widely utilized as a means of building organizations' knowledge stock (Cricelli & Grimaldi, 2010). Academic research carried out in universities may provide a way to improve firms' competitiveness, while universities are often characterized as the "engines of growth" (Laursen & Salter, 2004; Maietta, 2015). Universities, on the other hand, represent organizations performing at the highest level of education and knowledge creation in contemporary societies. During recent decades, several academic institutions have taken action to develop and facilitate a "third mission" by collaborating with users of new knowledge and enabling the transfer of

knowledge (Perkmann et al., 2013). Thus, successful university-industry collaboration promises a variety of benefits for both parties (P. D'Este & Patel, 2007; Gomes et al., 2005; Lee, 2011). In the collaboration, universities benefit from external research funding, opportunities to find practical applications for research results, access to industry skills and facilities as well as insights into new research fields. In the similar manner, effective research partnerships with universities enable industrial firms to absorb knowledge that may be critical for their future innovations and new product development, solve technological problems and gain access to critical human resources and new competences (Lee 2011).

2.1.1 University-industry relationships

University-industry relationships (UIRs) can be defined as "interactions between all parts of the higher educational system and the industrializing economy" (Ankrah, Burgess, Grimshaw, & Shaw, 2013). The research interest in UIRs is based on the belief that innovative research collaboration between these two parties can be a powerful driver and a source of jointly developed innovations (Ankrah et al., 2013; Cohen, Nelson, & Walsh, 2002; Rajalo & Vadi, 2017; Spencer, 2001). The number of these collaborative relationships has been increasing in the industrialized countries, due to pressures from both industrial and university sides (Giuliani & Arza, 2009). Factors generating pressures on industrial side include rapid technological change, shorter product development cycles, changing customer expectations and user trends, as well as tightening global competition – factors that have together radically changed the competitive environment for firms acting on the high technology areas (Ankrah & AL-Tabbaa, 2015; D. Teece, 2005; Wright, Clarysse, Lockett, & Knockaert, 2008). On the university side, the challenge of rising costs together with increasing problems with research funding have caused increasing pressures to seek collaborative relationships with external actors (Laursen & Salter, 2004). Moreover, there are increasing societal pressures on universities to be seen as "engines of economic growth" (Laursen & Salter, 2004), which is partly replacing the traditional societal expectations of acting as institutions merely providing highest education and generating scientific knowledge (Pennacchio, 2016). These pressures on both industry and academia have been leading to an increasing stimulus to develop university-industry links into direction that enhances innovation and competitive performance at institutional levels (e.g. countries and industrial or economic sectors) by transferring and exchanging knowledge between academic and industrial domains (Perkmann et al., 2013). In addition, collaborative relationships between industry and academia have widely been recognized as an effective way of enhancing

organizational capacity for open innovation – a process in which an organization utilizes a network of external partners in the process of innovation and knowledge development (Chesbrough, 2003; Enkel et al., 2009). Whereas open innovation probably cannot fully replace the traditional internal product development in the technology firms (Arora, Athreye, & Huang, 2016), it can be seen as a complementary option for innovative collaboration with external partners. In this manner, open innovation may provide the firm with newest technological or scientific knowledge, skills or competences that complement its internal innovation capabilities (Ankrah & AL-Tabbaa, 2015; Markman et al., 2008; Tether & Tajar, 2008). Recent literature has adopted the term "academic engagement" to represent the interactive process of transferring academic knowledge into the industrial domain (Ankrah et al., 2013; Perkmann et al., 2013). Perkmann et al. (2013, p. 424) have defined academic engagement as "knowledge-related collaboration by academic researchers with non-academic organizations". The interactions in this collaboration may involve formal activities, such as collaborative research, contract research, training, personnel mobility or contracting, whereas informal activities may include providing ad hoc advice or networking with practitioners (P. D'Este & Patel, 2007; Perkmann et al., 2013). Thus, academic engagement represents interorganizational collaboration practices and instances, which usually involve personal interactions (Cohen et al., 2002; Perkmann et al., 2013) in relationships between universities and industrial firms.

2.1.2 The role of knowledge in UIR collaboration

A central motivating factor in UIR collaboration is the building of partners' knowledge stock (Bellini et al., 2018). Firms engaging in UIR collaboration with academic institutions are usually primarily seeking opportunities for acquiring and developing new knowledge, which may potentially create a competitive advantage. New knowledge, along with skills and capabilities related to this knowledge, give firms the ability to develop new and innovative products, services and processes, and also to absorb new knowledge from outside their own boundaries (Bellini et al., 2018; Laursen & Salter, 2004). On the other hand, universities with a strong external collaboration ability and openness to interactions with industrial actors are generally highly capable of engaging in joint action with industrial partners (Pablo D'Este & Perkmann, 2011). Thus, those institutions that are capable of openly absorbing and exploiting knowledge from external sources have better possibilities for achieving good innovation performance (Lin, Wu, Chang, Wang, & Lee, 2012). This capability is referred to as absorptive capacity, defined as the firm's ability to "recognize the value of new

external knowledge, assimilate it, and apply it to commercial ends" (Cohen & Levinthal, 1990). Thus, according to the concept of absorptive capacity, organizations collaborating with external partners and jointly utilizing the results of this collaboration tend to be successful in achieving a competitive advantage (Cohen & Levinthal, 1990; Lin et al., 2012). In the context of university-academia collaboration, both sides of the relationship should be open to collaboration, knowledge transfer and knowledge creation (Bellini et al., 2018; Rajalo & Vadi, 2017).

Collaborative relationships between universities and industrial firms are often mediated by overlapping interactions and institutions that are usually complex in nature (Laursen & Salter, 2004; Siegel et al., 2004). Organizational barriers mediated by different norms and standards (institutional, organizational and cultural) tend to cause obstacles and barriers to UIR-based collaboration (Bruneel et al., 2010; Gomes et al., 2005). The key obstacle to UIR-based collaboration involves different institutional norms concerning public and private knowledge (Alexander, Martin, Manolchev, & Miller, 2018; Bruneel et al., 2010; Siegel et al., 2004). The university system is based on a long tradition of Mertonian norms of science, relying on the principles of communalism, universalism, disinterestedness and organized skepticism (Anderson, Ronning, DdeVries, & Martinson, 2010). Creation of scientific knowledge that is public in nature has been central to the growth of these organizations, leading to governmental support (Bruneel et al., 2010). Institutional norms based on the public nature of knowledge are fundamental to the manner in which many academics do their scientific work. In addition, the competitive mechanism and incentive regimes in universities are also strongly related to publication records, which, in turn, motivate university research staff to actively publish the results of their research work (Bruneel et al., 2010). On the other hand, a remarkable part of university research is practical in nature, focusing on solving technical, social or economic problems by utilizing the skills and capabilities of university research (Gomes et al., 2005). In several fields of academic research (such as engineering), the nature of applied research involves remarkable interaction with real-world industrial practices, and practical research problems may provide researchers with interesting opportunities to apply their research in practice and develop ideas in a real-life context. In these practically oriented areas, the norms of science operate in a somewhat different manner, compared to the strict Mertonian ideal of science, since researchers are often keen to engage in real-world research problems and interaction with industrial actors (Bruneel et al., 2010). Thus, academics working in different scientific areas and different research settings often have contradictory views on research collaboration with industrial partners (Welsh, Glenna, Lacy, & Biscotti, 2008).

In contrast to the academic principles of open and public knowledge, knowledge creation and utilization processes in the private sector are dominated by attempts to appropriate the economic value of knowledge. The value of knowledge is thus based on its potential to gain a competitive advantage (D. J. Teece, 1986). In this manner, knowledge in the private sector is largely closed and private in nature, remaining hidden within firms' boundaries or disclosed in a limited manner through patenting (Blind, Pohlisch, & Zi, 2018; Bruneel et al., 2010). However, knowledge sharing and transfer activities may sometimes be beneficial to private companies. For example, firms publish technical and academic papers, participate in open-source software projects or exchange information with their network partners. However, in these cases, openness to external actors is also typically used as a strategic mechanism aimed at gaining a competitive advantage (West et al., 2014). Given these two different types of norms and attitudes towards new knowledge, UIR collaborations are quite sensitive to conflicts related to selection of research topics or decisions about when and how research results should be published (Bruneel et al., 2010). Whereas researchers may be keen to openly publish their results, industrial partners may wish to keep them secret in order to protect the firm's competitive advantage (Blind et al., 2018). In a similar manner, researchers may wish to select research topics that are interesting from the viewpoint of their peers and research community, whereas industrial actors are likely to prefer topics that are valuable from the viewpoint of new product development for their customers (Nelson, 2004).

2.1.3 UIR collaboration

According to D'Este and Perkmann (2011), there are three main forms of university-industry collaboration (Table 2), firstly, *collaborative or joint research,* referring to formal R&D-based collaboration between universities and technology firms, which is often pre-competitive in nature (Hall, Link, & Scott, 2001). This kind of joint research may involve several academic and industrial partners, and is often subsidized by public funding. The results of this kind of collaboration are usually public. Another key form of university-industry collaboration is *contract research,* which refers to joint research activities between a university and a technology firm, directly related to the development of new products or services and, for this reason, of commercial relevance for the firm (Van Looy, Ranga, Callaert, Debackere, & Zimmermann, 2004). These kinds of projects tend to be financed by direct company funding, and the results of the research are typically owned by the company. The third form of collaboration, *consulting,* refers to research or advisory services provided to industrial clients by individual academics or groups of academics (Perkmann & Walsh, 2008). Consulting projects are

typically commissioned directly by the industrial client (Pablo D'Este & Perkmann, 2011). The main focus of this dissertation is on the first and second forms of UIR collaboration.

In the literature, UIR collaboration has often been characterized by a "cultural divide" between partners (Bruneel et al., 2010; Rajalo & Vadi, 2017). UIRs represent relationships between heterogeneous partners with different institutional norms and standards. For this reason, these relationships are often mediated by relatively high organizational barriers (Bruneel et al., 2010). This is because universities are open social institutions, which are primarily driven to create new public knowledge and provide education, therefore, prioritizing academic objectives, such as long-term research, academic publications and degree courses for students (Lee, 2011). In contrast, private firms are focused on capturing valuable knowledge that could facilitate competitive advantages in their business area through short-term research, which is directly associated with new product development and innovative functioning of the firm (Lee 2011; Bruneel et al. 2010).

Table 2. Three main forms of university-industry collaboration

	PARTNERSHIP	ACTIVITIES	FUNDING	RESULTS
COLLABORATIVE RESEARCH	Networked collaboration with several industrial and academic actors	Research work in a field of common interest but not yet related to specific products or services	Public funding instruments are typically in a central role	Research results are typically open
CONTRACT RESEARCH	The relationship between a university and industrial firm	Applied research, directly related to development of new products or services for the company	Typically, private company funding; public funding may be applied	Research results are typically company specific and usually kept confidential
CONSULTING	A direct relationship between academic researchers and their industrial clients	Research or advisory services	Direct company funding	Research results are typically company specific and usually kept confidential

Innovative collaboration between industrial and academic partners has been conceptualized as a higher-level process that involves many widely studied processes and practices, including collaboration, teamwork, management and coordination (Rajalo & Vadi, 2017). Decision-making processes in UIRs are typically challenging, not least because of the cultural and institutional differences between partners. How to overcome these deep-rooted differences and facilitate close and fruitful collaboration is typically a central concern for both academic actors and industrial managers (Bstieler et al., 2017). Development of mutual trust has been found to be one of the key facilitators of close collaboration in UIRs (Santoro & Saparito, 2003). A high level of trust is necessary because firms often need to share commercially sensitive information and tacit knowledge with their university partners. Moreover, high levels of trust between the university and firm also stimulate rich informational exchange and the sharing of valuable knowledge and information (Bstieler, 2006; Bstieler et al., 2017; Inkpen & Tsang, 2005; Santoro & Saparito, 2003). Along with a positive collaboration experience, mutual trust between collaborative partners also improves the effectiveness of the relationship between a firm and university (Bellini et al., 2018). Moreover, trust formation in the relationship is particularly important in UIRs since it is often very difficult to specify the actual results and implications of research, and the research process for the firm and university is beset with many unknowns (Bruneel *et al.*, 2010), as well as possible fear of opportunistic behavior on the part of the other partner. High levels of mutual trust in the relationship, however, can reduce this fear and resolve any problems that may arise in the relationship (Zaheer *et al.*, 1998; Inkpen and Tsang 2005), given that mutual trust allows partner to be confident that the other party is treating them fairly and in a consistent manner (Bruneel *et al.*, 2010).

Amabile *et al.* (2001) have suggested that three essential features characterize collaboration between industrial and academic partners: 1) the involvement of people who are members of different professions (academia and business); 2) collaboration between individuals or teams rather than between organizations; and 3) collaborators who are not all members of the same organization. Thus, organizations create the context and facilitators for the collaboration, while motivation for and continuation of long-term collaboration depends on the acting individuals and teams rather than on general organizational processes (Rajalo & Vadi, 2017). Furthermore, the use of different collaboration channels, as well as different levels of organizational hierarchy, have been found beneficial to collaboration (P. D'Este & Patel, 2007). This is because involving different organizational and hierarchical levels may help partners manage possible conflicts concerning orientation of the research and also align with different kinds of working orientation and culture in universities and companies (Bruneel et al.,

2010; P. D'Este & Patel, 2007). Previous research has also shown that positive experience of successful collaboration has a positive impact on further collaboration between partners and facilitates a deepening of their relationship (Azagra-Caro, Barberá-Tomás, Edwards-Schachter, & Tur, 2017; Bellini et al., 2018). This is because long-term collaboration between the same UIR partners helps both sides to learn from experience and develop the practices and working procedures of the relationship. Firms that collaborate over time with the same academic partners can also reinforce their R&D capabilities and create personal ties between the R&D personnel in industry and academic researchers by creation of working teams (Bellini et al., 2018). In this way, a positive experience of collaboration may enable UIR partners to converge in terms of attitudes and develop mutual understanding about the research process, as well as the practices of collaboration (Arvanitis, Kubli, & Woerter, 2008; Bruneel et al., 2010)

2.1.4 The role of education in UIRs

Creation and distribution of new knowledge belong to the primary goals of universities. Thus, universities provide theoretical and practical education to their students. However, involving university education in research-related collaboration activities provides a number of benefits for both universities and industrial actors (Muskett, 1996). According to Galán-Muros and Plewa (2016), education-related collaboration between academia and industry may occur through the following: 1) curriculum design and delivery, containing joint development of courses or entire degree programs and different kinds of planned experiences (such as excursions or guest lectures by delegates from external private or public organizations); 2) lifelong learning, including provision for adult education through which universities develop the skills and competences of people employed by industrial firms; and 3) student mobility, embracing the temporary movement of students from universities to industrial firms or other businesses. Furthermore, different kinds of student projects (often carried out as part of research collaborations taking place in UIRs) have a remarkable role in combining university education and activities related to external research projects (Arvanitis et al., 2008; Bruneel et al., 2010; Maietta, 2015).

2.2 Learning in university-industry relationships

As explained in the previous sections, industrial actors are increasingly seeking external opportunities to help them achieve and sustain innovation. By creating and maintaining collaborative relationships with universities, firms are typically able to increase their ability to acquire valuable new knowledge, and also

recombine new and existing knowledge (Laursen & Salter, 2004). Thus, networked collaboration with universities may provide firms with competences, knowledge and capabilities, and thus improve their innovation performance. In a similar manner, collaborative relationships with industry provide universities with practical know-how, opportunities for real-life application of research and scientific knowledge, as well as industrial experience (Lee, 2011). In UIR collaborations, universities transfer their own scientific knowledge to their industrial partners and, in turn, obtain experimental knowledge from industry. In this manner, knowledge creation and transfer mechanisms are often seen as being essential elements of UIR collaboration (e.g. Alexander et al., 2018; Cyert & Goodman, 1997; Weckowska, 2015). This is because these mechanisms are capable of transferring valuable new knowledge across the boundary between industry and academia, and also develop new research-based, technological or innovative capabilities with collaborative partners. Thus, relational learning in UIRs is an essential process within university-industry collaboration (Cyert & Goodman, 1997).

2.2.1 Relationship learning in UIRs

Creation and development of new knowledge through external sources is often critical to innovation. For this reason, the process of organizational learning is seen as a central part of organizational innovation (Cohen & Levinthal, 1990; Hurley & Hult, 1998; Lukas, Hult, & Ferrell, 1996). Organizational learning directly involves building mechanisms of collaborative know-how, which determine how effectively collaborations are managed (Cyert & Goodman, 1997; Simonin, 1997). Moreover, previous research has shown that relational-level learning (Larsson, Bengtsson, Henriksson, & Sparks, 1998), which takes place in knowledge-intensive external relationships, is able to improve the innovative performance and product development capabilities of technology firms (Cyert & Goodman, 1997; Hurley & Hult, 1998; Lin et al., 2012). The work of Selnes and Sallis (2003, p. 80) presents the concept of relationship learning and defines it as a joint activity between a supplier and customer, with two parties sharing information, which is then jointly interpreted and integrated into a shared relationship-domain-specific memory that changes the range or likelihood of potential relationship-domain-specific behavior. Thus, the process of relationship learning consists of three main phases: 1) knowledge sharing, 2) joint sensemaking and 3) knowledge integration. These three phases will now be reviewed from the viewpoint of relationship learning in university-industry relationships, and summarized in Figure 3 and Table 3.

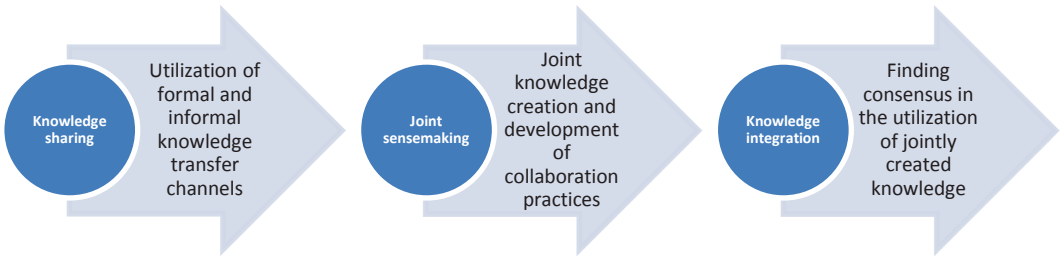

Figure 3. Three phases of the relationship learning process

Knowledge sharing

Knowledge sharing in relational-level interactions often refers to the process of knowledge transfer (Chang & Gotcher, 2007), which is broadly defined as an activity aimed at transferring knowledge or technology that may help either party to pursue their activities further (Arvanitis et al., 2008, p. 1866). In the context of UIRs, knowledge transfer comprises two-directional flows of competences, capabilities, skills and knowledge between academic and industrial partners (Phan & Siegel, 2006). This can occur across dyadic relationships or as a networked multi-partner collaboration, employing a wide range of knowledge transfer mechanisms or channels (Alexander et al., 2018). The variety of channels used in UIRs range from codified forms, such as publications and patents, to informal discussions or personnel mobility (Gertner, Roberts, & Charles, 2013). Thus, knowledge transfer channels used in UIRs may either be formal or informal in nature, depending on the presence or absence of a contract between the partners (Azagra-Caro et al., 2017). Formal knowledge transfer channels involve contract-based utilization of the knowledge, competences and equipment available in universities and industrial firms. Thus, formal knowledge transfer may take different forms in UIR collaboration, such as joint research projects, education and training, the mobility of academic personnel, joint supervision of masters' and PhD theses, and consulting (Arvanitis *et al.*, 2008). Informal channels involve access to academic and technical knowledge, expertise and skills through, e.g., training, recruitment or personal contact between academics and industrial actors without formal contracts (Azagra-Caro et al., 2017; Bekkers & Bodas Freitas, 2008; P. D'Este & Patel, 2007). Previous research (Mowery & Ziedonis, 2015) has shown that the use of different collaboration channels, as well as involving different levels of organizational hierarchy, can be beneficial to collaboration. This may help

partners manage conflicts concerning orientation of the research and also align with different kinds of working orientations and cultures in universities and companies (Bruneel et al., 2010; P. D'Este & Patel, 2007). Inter-organizational knowledge transfer is typically based on close personal-level relationships in which substantial knowledge exchange can occur and be sustained between partners (Dyer & Singh, 1998; Fang et al., 2011) in order to move knowledge from academia to industry, which is a process that requires engagement from both parties (Perkmann et al., 2013). Thus, knowledge transfer in UIRs can be seen as an essential part of the learning process since effective innovation collaboration requires partners to share their tacit, experience-based knowledge with each other. The role of tacit knowledge is essential in the knowledge transfer taking place in UIRs. While formally codified knowledge can be transferred in tangible forms (such as manuals, patents, reports or publications), the transfer of tacit knowledge involves a process of demonstration and learning through doing (Gertner et al., 2013; Roberts, 2000). This, in turn, makes the transfer of tacit knowledge more difficult and emphasizes the role of joint learning in an open and trusted atmosphere within the relationship between partners (Arora et al., 2016; Bellini et al., 2018).

Joint sensemaking

The second phase of the relational learning process is referred to as joint sensemaking. The purpose of this phase is to achieve a mutual understanding between partners through an interactive process (Selnes & Sallis, 2003; Weick, Sutcliffe, & Obstfeld, 2005). In joint sensemaking, partners make joint efforts to understand and make sense of the problem to be studied, and find explanations and solutions to it. Given that the knowledge resources and experience possessed by the partners in UIR collaborations are heterogeneous in nature (Estrada et al., 2016), the partners make joint efforts to combine this previous knowledge and jointly develop new experience-based tacit knowledge, which is difficult to transfer outside this relationship. However, in addition to knowledge resources, the partners participating in UIR collaboration are also heterogeneous (Rajalo & Vadi, 2017). As indicated earlier, remarkable differences in organizational cultures and norms may present challenges and obstacles in the collaboration (Bruneel et al., 2010; Gomes et al., 2005). Whereas the fundamental purpose of academia is to "produce codified theories and models that explain and predict natural reality", the industrial focus often lies in designing and developing "produceable and useful artifacts" (Pavitt, 1998). Thus, one of the central challenges facing collaboration partners is to build a mutual understanding and try to find a consensus by aligning their expectations, and combining their skills, knowledge and capabilities in order

to solve the problem (Chang & Gotcher, 2007; Kuwada, 1998). In this process, the partners' capability of creating new knowledge in collaborative relationships is emphasized. This often requires both academics and industrial actors to work on their UIR collaboration skills and to act as boundary actors (Siegel et al., 2004, p. 121). Boundary actors in UIRs operate across the boundary between universities and industry, and in this manner serve as a bridge between industrial firms and academics who operate in distinctly different environments (see Figure 4). These kinds of bridging mechanisms are often developed in UIRs over time, when the attitudes and collaboration skills of key persons on both sides of the relationship are developed, often through personal-level interactions and positive experiences in the collaboration (Bellini et al., 2018; Gomes et al., 2005). Thus, during the process of joint sensemaking, partners do not only learn to find solutions to the technical problems or challenges to be studied in the joint research, but they also learn how to collaborate with each other (Bellini et al., 2018).

A positive collaboration experience, accumulated over the long-term, is often seen as one of the most important facilitators of effective collaboration and knowledge creation in UIR relationships (Bellini et al., 2018; Bstieler et al., 2017). In long-term collaboration, parties learn from their experience and, together, develop richer and more refined ways of engaging with their research partners (Bruneel et al., 2010). Collaborative experience plays an especially critical role as research institutes (which already have experience of industrial collaboration) are likely to be approached again by their industry partners for further projects (Arvanitis et al., 2008; Perkmann et al., 2013). These factors also help partners build the mutual trust that is seen as a key enabler of efficient knowledge creation and joint sensemaking in such relationships (Bstieler et al., 2017). This kind of shared experience, along with knowledge that is jointly developed and accumulated in the relationship, is among the primary drivers of industrial innovation and product development outcomes (Verona, 1999), while also being recognized as the facilitator of more efficient and innovative future collaboration between research partners (Bruneel et al., 2010).

Knowledge integration

The third phase of the relationship learning process relates to the integrating the jointly developed knowledge into the relationship-specific memory structures (Fang et al., 2011; Selnes & Sallis, 2003). This kind of relational memory may involve knowledge relating to relational structures and practices, routines, experience-based competences and capabilities, as well as jointly developed products or services (Lukas et al., 1996; Moorman & Miner, 1997). In the phase of

knowledge integration, the partners may also implement the results of their joint development and learning as concrete outcomes, which can be utilized in industrial commercialization processes or academic outcomes (Perkmann et al., 2013). Therefore, this phase is often referred as knowledge implementation or institutionalization (Crossan, Lane, & White, 1999; Kuwada, 1998), as the jointly created, developed, shared and combined knowledge from individual partners becomes the property of the relationship, and the participating organizations (Lukas et al., 1996; Moorman & Miner, 1997). In UIR-based collaboration, the academic and industrial partners typically have different interests related to the utilization of the jointly achieved research results. The highest priority of the industrial partner is usually related to the utilization of the research results in the development of new products or services, and in this manner improve and sustain the competitiveness of the firm (D. J. Teece, 1986). This means that the industrial interests to the utilization of the research results are directly related to the commercialization (Markman et al., 2008). The commercialization of university-based innovations has been considered as a prime form of the societal impact of the academic research, because it constitutes immediate and measurable market acceptance for the results of academic research (Markman et al., 2008; Perkmann et al., 2013). However, the commercial interests often require the firm to keep the results of the joint research secret. On the other hand, the priority of the academic party is to publish the research results obtained in the UIR collaboration. This is because creating open and public new knowledge is a basic principle of the academic system, and the academics working in the university research have to create and maintain their publication records to ensure the sustainability of their academic career (Arvanitis et al., 2008; Bruneel et al., 2010; Geuna & Nesta, 2006). For this reason, establishing expectations concerning what aspects of and when the results of the joint projects can be published by the university researchers may be controversial (Bruneel et al., 2010). However, the innovative performance of the firms engaging in the UIR collaboration depends largely on how successful the industrial actors are at appropriating the knowledge developed in the collaboration with the academic partner (Laursen & Salter, 2004).

Previous research (P. D'Este & Patel, 2007) has shown that the results of university-industry collaboration seldom yields to specific inventions or innovations that could be directly commercialized, and it is often difficult to empirically evaluate the direct impact of UIR collaboration on industrial innovation. As the main industrial motivation to collaborate with universities is to commercialize university-based technologies for financial gain (Siegel et al., 2004), gaining understanding of the industrial commercialization process is also very important to academics (Perkmann et al., 2013) when engaging in industrial collaboration. Similarly, to obtain the best possible outcome from the

collaboration with academic partner, the industrial partner needs to understand the academic priorities and university partner's way of working. In this manner, to facilitate successful knowledge integration and utilization, both UIR partners need to develop their collaborative processes and mutual understanding (Bellini et al., 2018).

Table 3. A summary of the relationship learning in UIRs

	KNOWLEDGE SHARING	**JOINT SENSEMAKING**	**KNOWLEDGE INTEGRATION**
MAIN GOAL	To facilitate formal and informal knowledge transfer in the UIRs by using two-directional flows of competences, capabilities, skills, and knowledge between partners.	To achieve a mutual understanding between partners, and jointly develop new knowledge in a shared learning process	To transfer the jointly created, developed, shared and combined knowledge to the property of the participating organizations.
KEY PRACTICES	*Formal knowledge sharing*: Joint research projects, education and training, the mobility of academic personnel, the joint supervision of masters' and PhD theses, and consulting. *Informal knowledge sharing*: Training, recruitment, or personal contacts between academics and industrial actors	Shared process of joint knowledge creation based on the partners' previous knowledge, experiences, and capabilities as well as new experimental knowledge developed in the relationship	High levels of absorptive capacity Willingness to facilitate knowledge implementation
FACILITATORS	Use of different collaboration channels and involving different organizational levels Developing personal-level interaction Engaging in the collaboration and developing mutual adaptation	Building mutual understanding and aiming at finding consensus by aligning partners' expectations, and combining their skills, knowledge and capabilities. Developing trust through personal-level interactions and positive experiences on collaboration	Building mutual understanding on the utilization of the research results Developing partners' collaborative processes and mutual understanding to improve adaptation

2.2.2 Learning practices in UIRs

The analysis of learning practices and mechanisms in UIRs can be based on the practice-based view of knowledge and learning. The practice-based view of learning favors the term "knowing" to the more conventional terms of "knowledge" or "ability" (Amin & Roberts, 2008; Weckowska, 2015), to emphasize the role of knowing as active part of action (or practice) (Duguid, 2005), and knowledge is seen as an object that can be possessed by organizations or individuals. Therefore, practice theory concerning learning has developed its own framework for analyzing the role of learning in shaping the organizational practice (Weckowska, 2015). This theory is based on situated learning theory (Amin & Roberts, 2008; Brown & Duguid, 1991), which makes it suitable for analyzing the learning processes in in relational context (Weckowska, 2015). This is because practice-based view of knowledge focuses on the positive outcomes and results of learning by assuming that any change in organizational practice that results from the learning process can be beneficial for the organization. Therefore, this view sees that "knowing" is embedded in the practices and can be deduced from observing the "doing" (Orlikowski, 2002), which both are seen as inseparable elements of practice (Gheradi, 2000). Thus, the existing practice in the organization can be seen as a medium for learning through social practice, and the actions the organizational members already do and the information what they already know has an influence on their learning and what kinds of organizational changes they may make. The organizational practice can also be seen as a source of inertia in the organization, since it reflects the organization's local "regime of competence" and the local view of world as it is seen by organizational members. As the local understandings of surrounding world and internal competences co-evolve with social practices, changes in practices and the regime of competences have to take place concurrently (Weckowska, 2015). In this manner, organizational practice may become source of inertia, since the organizational members who enact it often resist the organizational changes that they feel to undermine their capabilities, competences and current working practices (Mørk, Aanestad, Hanseth, & Grisot, 2008).

According to the practice-based understanding, the learning shapes the organizational practices (Weckowska, 2015; Wenger, 1998). When this type of learning takes place inside the organization, the organizational members are able to learn through participation in social practices in their organization. This process is referred as learning in local communities of practice (CoPs) (Amin & Roberts, 2008; Brown & Duguid, 1991), in which knowledge is socially constructed in shared activity and interaction within informally formed groups of individuals involved in the practice. In this kind of informal interaction, the role of the creation

of tacit knowledge is emphasized (Duguid, 2005). However, when the individuals represent different organizations, they participate in the process of inter-organizational learning on individual level. Thus, in addition to intra-organizational learning, the CoPs approach has been used to analyze and learning process in a wide variety of inter-organizational learning environments (Gertner et al., 2013). In these kinds of networks, knowledge can be shared between individuals having heterogeneous but at least partly overlapping knowledge bases. Following (Gertner et al., 2013, p. 633), Figure 4 presents the interactions in the UIR by showing industrial and academic partners as CoPs members within their own organizations, and the associates as gaining memberships through the adoption of dual identity by having ability to participate competently in both CoPs. In this manner, both academic and industrial partners are participants of CoPS in their own organizational structures, but the UIR collaboration enables them to reach across to the CoPs of the partner organization. In this, the role of boundary actors (Siegel et al., 2004, p. 121) is critical. In the figure 4, part of the associates with either company identity of university identity may operate across the boundary between universities and industry, and in this manner serve as a bridge between these two partners.

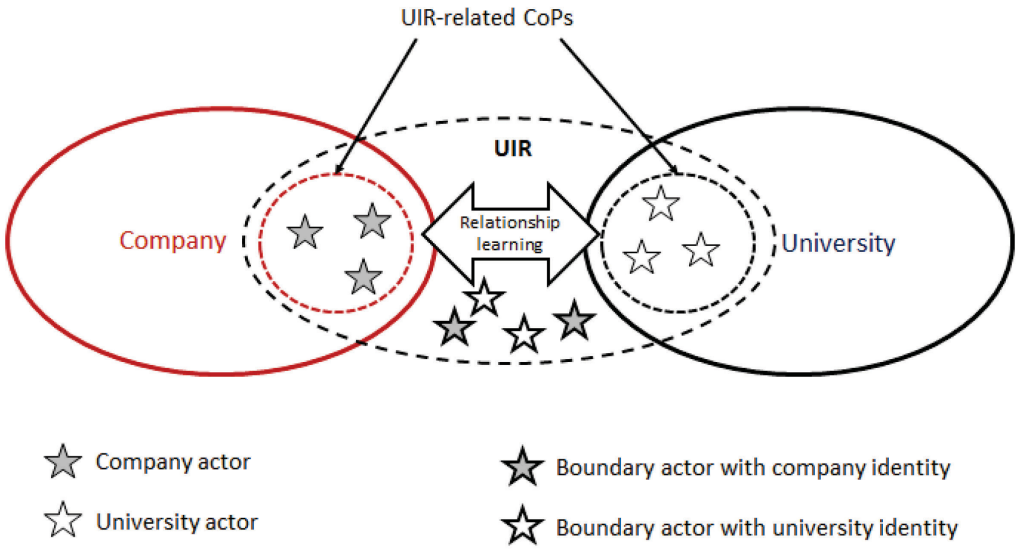

Figure 4. Communities of practice (CoPs) in UIRs.

According to the theory of situated learning, this kind of learning in relevant interaction with other individuals representing other organizations results in incremental changes in organizational practice (Amin & Roberts, 2008). The easiness of sharing knowledge and learning in these networks within organizations or crossing organizational boundaries may depend on many factors such as

different languages (or professional jargon), norms, values, or individuals' views of the surrounding world (Brown & Duguid, 1991, 2001). However, this kind of interactive collaboration provides opportunities for sharing and developing new ideas, developing of new working procedures and developing competences through shared process of joint sensemaking (Tagliaventi & Mattarelli, 2006).

3. RESEARCH DESIGN AND METHODOLOGY

This chapter describes the research design of the dissertation, including philosophical assumptions underlining the research approach, strategies as well as research methods used. Quality assessment issues related to the validity and reliability of the study are also covered in this chapter. The research design process involves with the choices related to the research process. The empirically studied phenomenon guides this whole process as well as the methodological choices. Research design also describes a set of assumptions and considerations connecting the underlying theories to the methods and techniques used for collecting empirical material (Jonker & Pennink, 2010, p. 39). Thus, the process of research design involves with finding answers to the research question by means of the selection of data sources as well as approaches to data collection and analysis. The research "onion" (Saunders, Lewis, & Thornhill, 2009, p. 108) is often used to visualize the layered structure of the philosophical and methodological choices related to the research design. Following these layers, this chapter discusses the underlying philosophical assumptions and premises as well as the ontological, epistemological and methodological choices of this study following the structure adapted from the research onion (Saunders et al., 2009) presented in Figure 5.

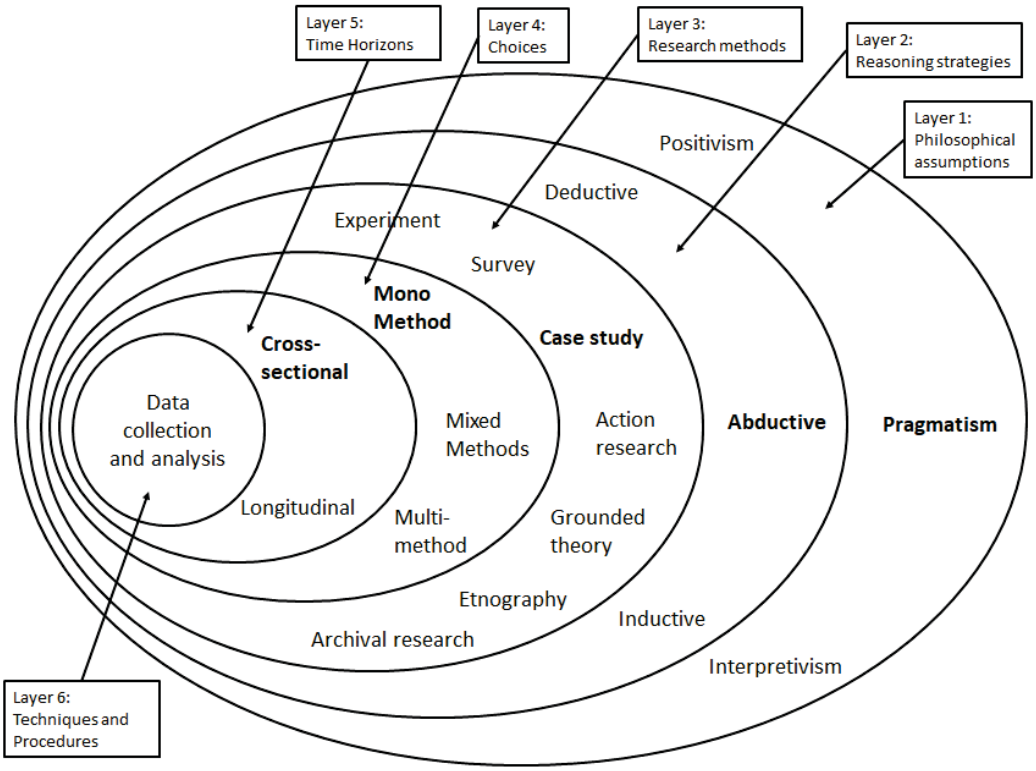

Figure 5. The research onion.

3.1 Philosophical assumptions

The philosophical assumptions in science are always influenced by the researcher's subjective views and mindsets, which form a lens through which the researcher may view the phenomena to be studied. Research work in the field of social sciences always represents researcher's understanding on the surrounding social world, and how research may improve understanding of this world. Scientific work and research paradigms are based on ontology, epistemology, and methodology (Burrell & Morgan, 1979; Guba & Lincoln, 1994, p. 108). Ontology refers to a researcher's understanding and assumptions of the world and reality. Thus, ontology is defined as the science of being and therefore it is related to the question of whether objective reality exists, or whether the reality is produced through individual and subjective cognition (Burrell & Morgan, 1979). Epistemology represents the theory of knowledge, which is related to the question of how the social reality can be known. In this manner, epistemology reflects the way how we perceive the world, and how scientific research may increase our knowledge on the phenomena being studied (Burrell & Morgan, 1979). Methodology of the research depends on the philosophical assumptions made, and therefore ontology and epistemology determine the chosen methodology (Guba & Lincoln, 1994, p. 108).

Paradigm is a term used in the social and behavioral sciences to represent fundamental assumptions, common beliefs, agreements or frameworks supported by theories and practices that guide a researcher in exploring, understanding, and addressing the research problems in a research discipline (Guba & Lincoln, 1994; Jonker & Pennink, 2010). The work of (Burrell & Morgan, 1979) presents four common paradigms used in sociological research. These paradigms complement the division to three categories presented above by presenting the four paradigms, *radical humanist, radical structuralist, interpretative, and functionalist paradigm* as a two dimensional matrix, namely in the continuum from regulation to radical change, and the continuum from subjective to objective, as presented in Figure 6. The horizontal subjective-objective dimension views the nature of science. The subjective paradigms in the left consider the world from the individual view, as a product of one's mind and cognition, and thus they follow interpretive research tradition. On the right side, objective paradigms consider the world in objective manner, from the reality perspective, following the positivism. The vertical dimension considers the nature of society ranging from regulation in lower part, to radical change in the upper part, making distinction between interpretive and critical research. The *interpretive studies* highlight the meaning of regulation as a driving force for the change of society (Burrell & Morgan, 1979), whereas in the *critical studies,* the existing environmental and social reality evolves over time,

and thus critical theory attempts to change the currently used ways of doing things (Burrell & Morgan, 1979).

Whereas the work of Burrell and Morgan (1979) identifies the above-mentioned four fundamental paradigms for social sciences, the categorization of Guba and Lincoln (1994) presents four paradigms: *positivism, post-positivism, critical theories* and *constructivism*. Despite differences in their categorizations, the fundamental foundations of them is relatively close to each other, and their purpose is to guide the researcher through ontological, epistemological, and methodological choices made in the study (Burrell & Morgan, 1979; Guba & Lincoln, 1994).

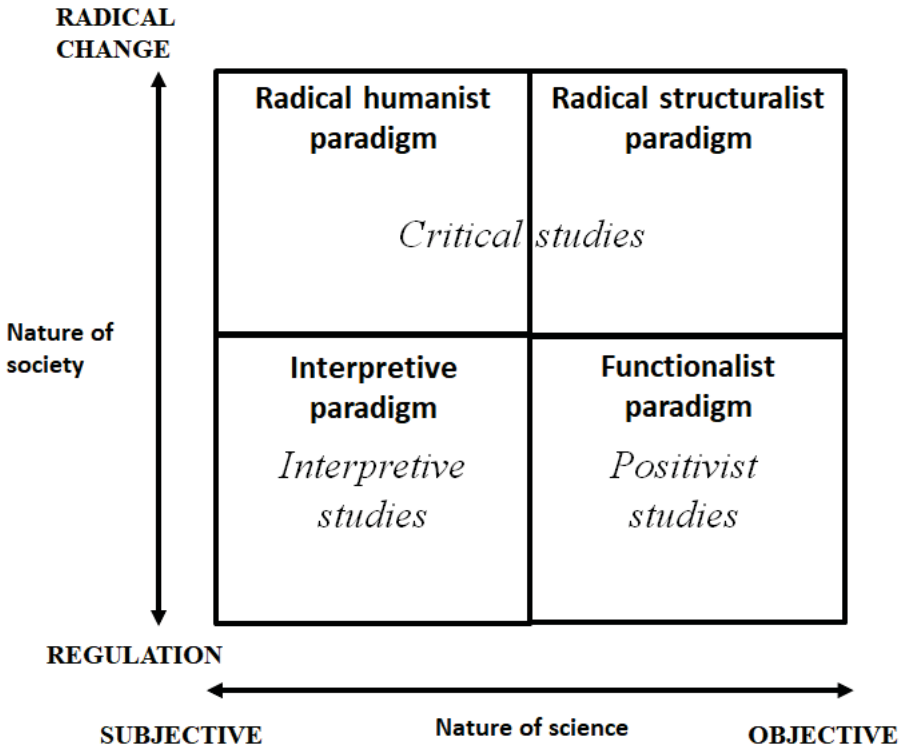

Figure 6. The four paradigms for sociological research.

3.1.1 Ontological choices

The ontological discussion is related to the nature of the social world. Burrell and Morgan (1979) view the ontology as a continuum from realism to nominalism, where realism consider the social world to exist even before one is born, and that is not something that individuals could create or modify. Nominalism, on the other

hand, considers the social world to be constructed and modified by actions of individuals participating to it. In this continuum presented by (Burrell & Morgan, 1979), this dissertation represents nominalism, since it studies the relationships between organizations created, maintained and modified by humans, and also the actions of individuals involved in these relationships.

3.1.2 Epistemological choices

Academic research made in the field of management or organizations is typically located in the lower area of the matrix presented in Figure 6, because an assumption of regulation fits better to the understanding of society and the environment of the organizations, than an assumption of radical change. The epistemological choices related to a research focus on the discussion of the nature of knowledge. Burrell and Morgan (1979) consider the epistemological views on the continuum from positivism to anti-positivism. Thus, in the 2x2 matrix of Burrell and Morgan (1979) (Figure 6), *positivist* studies assume that the environment is similar to everyone, and thus it is not dependent on the observers' perceptions (Guba & Lincoln, 1994). Positivism thus assumes the researcher's objective role in the research, and therefore positivist studies relying on the highlighting rational and logical approaches based on causalities and regularities are mainly meant to test theories. In the field of management and organizations, quantitative studies follow the principles of positivism, are positioned to the area of functionalist paradigm (Örtenblad, 2002) in the 2x2 matrix. This is because quantitative research assumes that the organizational environment consists of causal relationships and logical processes that can be explained by hypothesis testing.

Studies based on *interpretivism* (also known as *anti-positivism*), on the other hand, assume that the individuals may sense the same occasions in different manner. In this manner, interpretivism sees that the social world can be understood only when the researcher is directly involved with the activities to be studied, and aims at understanding the phenomenon "from inside" (Burrell & Morgan, 1979, p. 5). Interpretive studies have their basis in hermeneutical principles, interpretation and in-depth understanding of the subject. For this reason, in interpretive research, the observations made by the researcher go hand in hand with the theory. Thus, qualitative research approaches, such as case study method, belong to the area of interpretative paradigm. This is because interpretative paradigm considers individual cognition and individuals' subjective behavior in organizations (Easton, 2010). In this manner, the case study approach used in this dissertation follows the principles of interpretivism, and belongs

mainly to the area of interpretative paradigm in the matrix of Figure 6. However, it should be noted that the case studies in this dissertation employ research methods that aim at increasing objectivity, which may better fit to the area of functionalist paradigm. Triangulation is one example of these kinds of methods, typically used in qualitative research. In the interpretive studies considering organizations, it is usual that both subjective and objective elements are used (Kakkuri-Knuuttila, Lukka, & Kuorikoski, 2008).

In between the two extreme views of epistemology, positivism and interpretivism, is the view of pragmatism. Pragmatism view recognizes that there exist several different ways of interpreting the world and undertaking research, and that no single point of view can ever give an entire picture and there may be multiple realities (Saunders et al., 2009). In this manner, pragmatism does not consider the truth as an absolute, but rather as an information that is open to renewal and criticism, and that may be useful to researchers (Easton, 2010). In this manner, science can be seen as a means to obtain the best possible explanation to the question to be studied (Peirce, 2001). Moreover, according to the pragmatists, creating new information and knowledge is always a process influenced by the researchers' prior understanding, assumptions, beliefs, and views on their research area (Peirce, 2001).

Epistemologically this dissertation follows the principles of pragmatism. The author of this dissertation has long-term experience on working with university-industry relationships, both in academic and industrial institutions. This experience has also encouraged her to start research work on this particular area, and to seek answers to the research questions of this dissertation. The practical prior experience on the field of university-industry relationships has thus influenced on the selection of the research topic, defining the research gaps, and a number of empirical choices during the research.

3.2 Scientific reasoning

Scientific reasoning refers to a strategy that is applied in the research to draw conclusions based on empirically collected data. The reasoning strategies are usually divided into three possible approaches, deductive, inductive and abductive reasoning. Inductive reasoning is initiated from the empirical material concerning the phenomenon to be studied, and the theory is developed based on the findings obtained from the empirical data. Deductive reasoning, on the other hand, follows strictly the existing theory, and uses the theory to form a set of hypotheses to be tested. In their purest form, both inductive and deductive reasoning strategies

cause problems in practical research (Perry, 2005). Pure induction actually prevents the researchers to use previous results of research as reference to his or her research. In the same manner, deduction in its purest form prevents the researchers to develop existing theories based on their new findings. Due to these problems with inductive and deductive reasoning, the studies following interpretivism and pragmatism often employ abduction as their reasoning strategy (Easton, 2010). Abduction is a reasoning strategy that promotes continuous interplay between theory and empirical findings. In abductive reasoning, the research process moves continuously between theoretical aspects and empirical data in an attempt to find the best available explanation to the research question (Dubois & Gadde, 2002; Peirce, 2001). In the scientific reasoning, this dissertation relies mainly on the abduction. The continuous interaction between theoretical aspects and empirical data is evident in the articles of this dissertation. In all the articles, the empirically collected interview data is discussed and reflected to the selected theoretical framework, and conclusions are drawn based on this kind of abductive reasoning.

3.3 Research methods

The purpose of this dissertation is to analyze the learning practices in the collaborative relationships between universities and industrial actors. This dissertation aims at improving understanding on the relational-level practices and mechanisms that facilitate efficient long-term learning relationships between academic and industrial actors. The design of this dissertation is based on four articles studying the practices of learning in UIRs. Qualitative research approach was selected, it because offers insights to complex social processes of the mutual learning and joint knowledge creation in UIRs (Gertner et al., 2013, p. 633). These kinds of insights would be difficult to obtain from quantitative data (K. M. Eisenhardt & Graebner, 2007). All the articles employ qualitative case study method, which means that the main methodology in the dissertation is based on the case study method with multiple cases (K. Eisenhardt, 1989). Multiple case study method represents "a research method that involves investigating one or a small number of social entities or situations about which data are collected using multiple sources of data and developing a holistic description through an iterative research process (Easton, 2010, p. 119)." Additional advantages of the case study method include the richness of the data , and variety of its sources (Yin, 2009), which makes it possible for the researcher to come closer to the constructs and to illustrate causal relationships more directly (Siggelkow, 2001). On the other hand, the weaknesses of the case study method include over theorizing and the lack of generality of the theory cases (K. Eisenhardt, 1989).

In general, the case study approach has been found to be beneficial research method particularly in the situations where the purpose of the research is to understand complicated relational phenomena in industrial context, which are often evolving in nature (Beverland & Lindgreen, 2010). In these kinds of situations, typical research questions are "how" and "why" questions, which can be explanatory in nature (Yin, 2009). The main research question of this study: *What kinds of collaborative practices facilitate learning in long-term university-industry relationships?* aims at explaining the mechanisms and practices behind the formation and development of learning relationships in long-term UIRs. In this manner, the main research question and its sub-questions represent typical *how* questions that are particularly suitable for case studies focusing on relational-level phenomena with complex set of factors and interactions (Easton, 2010). The relational phenomena, such as personal-level interactions, decision procedures and collaboration practices, are usually related to the organizations and relationships that are difficult to access, and often complex in structure (Easton, 2010). As a result of case study of relatively small number of entities (cases), can provide a great deal of qualitative data offering insights into the nature of the real-life phenomena being studied (Easton, 2010, p. 118).

3.4 Choices

When finding answers to the research questions, the researcher may either use a single data collection technique, referred as *mono-method*, or take an approach containing several data collection and analysis procedures, referred as *multi-method* (Saunders et al., 2009, pp. 151–152). The mixed method approach refers to a research approach, in which both qualitative and quantitative data collection and analysis are used, either at the same time (parallel) or one after the other (sequential). This dissertation concentrates on the qualitative case study methods relying mainly on the utilization of interview data. In this sense, the dissertation follows the mono-method approach.

3.5 Data collection

The process of data collection includes the selection of the cases, data gathering, data analysis as well as reporting (Saunders et al., 2009). In the case-based research methodology, the definition of the sample size is often a critical issue, despite the fact that the previous methodological literature concerning case study methods does not provide suggestions for the selection of the optimal number of cases (Easton, 2010; Woodside & Baxter, 2013). Eisenhardt (1989), for instance,

suggest in her widely cited paper on case study method that "while there is no ideal number of cases, a number between 4 and 10 cases will usually work out well". Thus, in the qualitative case study methodology, the sample size cannot be large enough to qualify the statistical interference that could provide basis for explanations of causality. In this manner, the case-based methodology does not fulfill the objectivity demands of positivism, despite the fact that regularities and law-like generalizations in the case-based data might provide basis for explanations of causality (Easton, 2010, p. 118). However, in the interpretivist studies, the researchers create their own interpretations on the cases, and in this manner aim at understanding the phenomena to be studied based on these interpretations. The views of pragmatism follow this kind of thinking, and justify the use of case study method by the assumption that the case study method provides possibilities to study the research problem in great details in its context (Easton, 2010, pp. 118–119).

To ensure that the cases used in the case study are representative enough, and provide rich information content to make interpretations on the phenomena being studied, the selection of the cases used in the multiple case study methodology is important. In the case studies used in this dissertation, the cases for the studies were selected purposively rather than randomly. Harper (2001 p. 27) argues that "a small number of well-informed informants are, in fact, a better sample than much larger samples of minimally involved subjects". This kind of approach of "purposeful sampling" is drawing on the concept of the information-rich case studies (Patton, 1990). Moreover, according to (Patton 1990, p. 169): "The logic and power of purposeful sampling lies in selecting information-rich cases for study in-depth. Information-rich cases are those from which one can learn a great deal about issues of central importance to the purpose of the research, thus the term purposeful sampling."

In the case-based research, in depth data collection typically involves multiple sources of data with rich information content. The data sources can be for example people, different documents and databases, or other printed materials. When the case studies focus on the relational-level phenomena, such as in this dissertation, the main data collection approaches include typically on-site interviews and observations in real-life situations (Beverland & Lindgreen, 2010; Woodside & Baxter, 2013). The data used in the articles of this dissertation comes mainly from the interviews, even though secondary data sources such as written documents, reports, publications and company-specific information are also used.

3.6 Reliability and validity

To confirm the reliability of the studies used in this dissertation, data triangulation methods were used (Beverland & Lindgreen, 2010; Huberman & Miles, 1994) involving the analysis of data from the websites of the firms and university research groups, along with other materials, such as reports, brochures, publications, and other written documents both before and after interviewing each side of the relationship. Given that, during qualitative interview-based data collection, informants' personal opinions, views and experiences on the relational practices and the experiences on the history of the relationship tend to be interpretative in nature, the researchers controlled and discussed their findings during the process of data collection. This was carried out by comparing the collected interview data from both sides of the relationship, as well as by posing additional questions (Brennan & Turnbull, 1999). When analyzing the results, the researchers read the interview transcripts thorough several times, paying attention to cross-checking each other's interpretations and findings concerning the data (K. Eisenhardt, 1989). After the initial analysis of the results, the key findings on each interview were reviewed with the interviewee to discuss and reflect on the findings and interpretations. In this stage, open questions were also posed to the interviewees in order to validate researchers' conclusions.

4 SUMMARY OF PUBLICATIONS

The main goal of this dissertation is to address to the research questions defined in the Introduction. This objective is delivered by means of four articles following the main body of this dissertation, each of which have their own viewpoint to the general objective of the dissertation. This chapter presents an overall summary of the goals, research questions, key results as well as contributions of the four articles included in this dissertation.

4.1 Article 1: Balancing learning and knowledge protection in university-industry collaborations

The previous literature widely agrees that knowledge transfer and learning taking place in UIRs enable technology companies to absorb information, knowledge, skills and capabilities that may be critical to their innovative performance and R&D outcomes. However, as explained earlier in this dissertation, one of the main obstacles in the knowledge transfer and learning in UIRs involves with different norms and attitudes concerning private and public knowledge. For university actors, the creation of open knowledge to be published in scientific or practical forums is often a top priority. On the other hand, industrial partners' interest on the new knowledge is related to the economic value of the new knowledge, which often requires to keep the knowledge private. For this reason, the UIR partners are often facing a dilemma how to enable learning and open knowledge transfer in the relationship, and in the same time protecting the company-sensitive knowledge.

Article 1 aims to improve understanding how the UIR partners can cope with the competing demands between learning and protecting in long-term UIRs by finding answers to the research question: ***Q1. What practices help industrial firms to achieve a balance between learning and knowledge protection in UIRs?*** Thus, the objective of the article is to identify the practices that facilitate mutual learning and joint knowledge creation, but in the same time maintain the confidentiality of the company-sensitive knowledge. The article also studies relational learning practices that may lower these knowledge-based barriers related to the different norms concerning private and public knowledge. Theoretical framework of the article is developed on the three phases of relationship learning, originally suggested by (Selnes & Sallis, 2003): knowledge sharing, joint sensemaking, and knowledge integration, and the collaboration practices are analyzed in these three phases. The methodology of the article is based on qualitative case study approach, in which six long-term UIRs from IT industry were studied. The results of the study are summarized in Figure 7. They

reveal that the development of mutual trust that is based on the personal relationships as well as mutual adaptation help the partners to overcome the barriers of the collaboration. Related to the openness of the jointly created knowledge, the results show that the partners in long-term relationships are able to develop practices that enable them to reach consensus on the utilization of the research results in a manner that is satisfactory for the both parties.

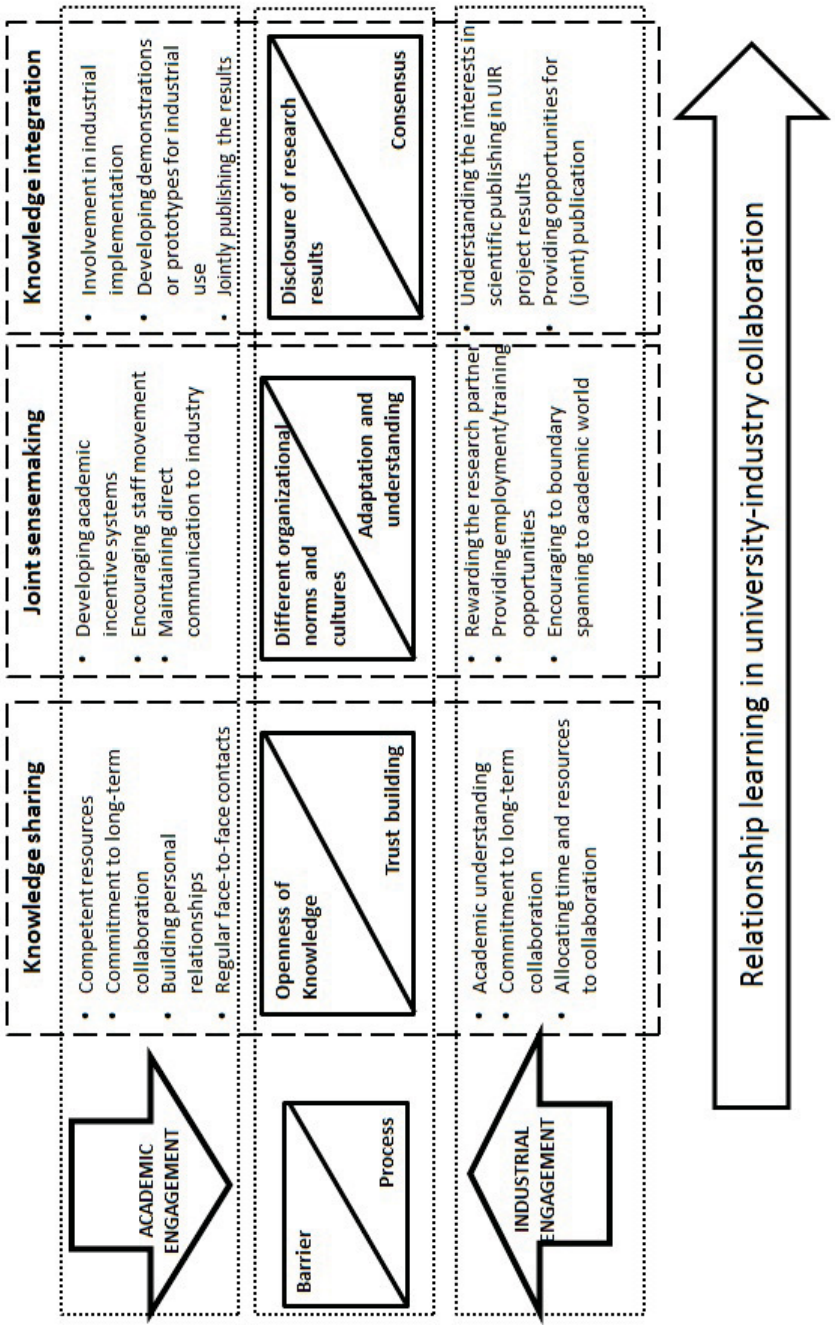

Figure 7. Summary of learning practices identified in Article 1.

4.2 Article 2: Educational involvement in innovative university-industry collaboration

Innovative research collaboration within UIRs may effectively facilitate joint knowledge creation and mutual learning. Consequently, a remarkable body of previous research has been focused on the knowledge transfer between academia and industry. However, despite the fact that the creation and distribution of scientific knowledge is among the primary goals of universities, the role and meaning of educational involvement taking place in the research collaboration between industry and academic is almost a neglected topic in previous research concerning UIRs. Even though the previous studies mention typical forms of joint educational activities in UIRs, such as collaborative courses, jointly organized training, or different kinds of student projects, as facilitators of deepening the collaborative relationships, they do not address the questions on *how* educational involvement in UIRs facilitate mutual learning and joint knowledge creation.

Article 2 aims to fill this gap by intending to answer the research question: ***Q2. How can educational collaboration facilitate relational learning and knowledge creation in university-industry relationships?*** Thus, the objective of this study is to improve understanding on the practices of educational involvement as facilitators of joint learning and knowledge creation in UIRs. As in the Article 1, also in Article 2 the theoretical framework is developed on the concept of relationship learning (Selnes & Sallis, 2003), and the results are analyzed in terms of three phases of this learning process. Article 2 is a qualitative case study consisting of nine UIRs in Finland, all representing close and long-term research collaboration combined with remarkable educational involvement directly contributing to the mutual learning and joint knowledge creation in the UIRs. The data collection in this article is based on case interviews focused on UIRs between universities and technology firms in Finland. Based on the interview data, four main forms of educational involvement were identified: 1) student projects for undergraduate students, 2) thesis projects, 3) tailored degree courses, and 4) jointly organized courses. The results were analyzed in terms of three phases of the relationship learning, including , 1) knowledge sharing, 2) joint sensemaking, and 3) knowledge integration (Selnes & Sallis, 2003), and summarized in Figure 8.

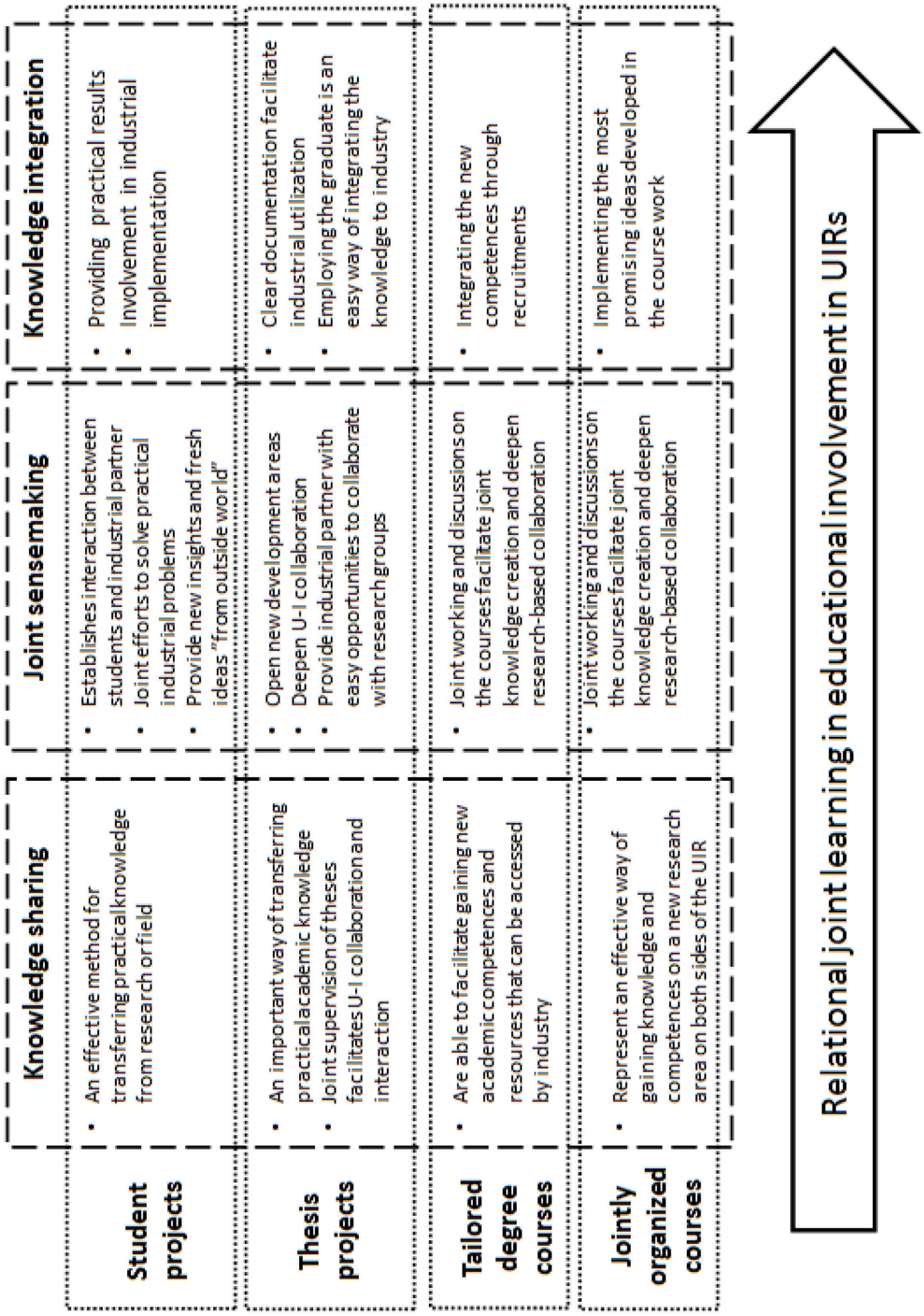

Figure 8. Summary of the main findings of Article 2.

As summarized in Figure 8, the case study provided several collaborative educational practices that may facilitate the relationship learning in UIRs. First, involvement of students in UIR-based research projects provide a practical avenue for fresh insights, viewpoints and ideas to customer experience, and efficient way

of recruiting new competences to the industrial domain. Second, jointly organized courses and other education provide an efficient way of gaining industrial skills and competences, and also transfer new knowledge to both directions in the UIRs. Third, all the forms of educational involvement in the UIRs help the industrial partners to understand and absorb the scientific knowledge transferred from academic world to industrial domain, and also utilize this knowledge in industrial purposes. Fourth, the educational involvement deepens the mutual understanding and adaptation in the UIR, which makes the relationship more effective.

4.3 Article 3: How doctoral students and graduates can facilitate boundary spanning between academia and industry

Effective knowledge transfer between academia and industry is one of the main challenges in the UIRs. Since the knowledge created, developed, and shared in the UIRs is often experimental and tacit in nature, it should be possible to transfer to the collaboration partner in a form that the partner is able to absorb and utilize it. For this reason, transfer of the knowledge requires significant personal interaction from the stakeholders of the UIRs. One of the most important ways of transferring knowledge over the boundary between academia and industry is to facilitate the mobility of academics to industry, and vice versa. Thus, the ability of boundary spanning is an important capability for actors, either academics or industrial, who actively aim at transferring the knowledge between academic and industrial domains, and in this manner facilitate effective joint learning in UIRs. When these boundary actors people move over this boundary, they also have to cross various organizational barriers caused by different organizational and cultural environments and norms followed by industrial and academic organizations. For this reason, the boundary between industry and academia may represent obstacles to close collaboration, and in many cases academic research staff have limited connection to the real-world industrial work. However, to improve the capabilities of industrial engagement among young researchers, universities have started to involve industrial actors in the doctoral education. By means of this collaboration, doctoral students and graduates are able to obtain industrial experience and understanding of industrial way of working, which in turn gives them capabilities for boundary spanning.

The goal of Article 3 is to study the role of doctoral candidates and doctoral graduates as boundary actors between academia and industry. By engaging in the industrial domain, these actors may serve as a bridge between academia and industry, and facilitate effective transfer of newest scientific knowledge to

industrial domain. The focus of the article lies in the doctoral education programs organized jointly between universities and industrial actors, aiming to improve the students' capabilities in the boundary spanning between academia and industry. The Article aims at answering to research question: ***Q3. How can jointly organized doctoral education programs facilitate the mobility of doctoral students and graduates from academia to industry?*** Thus, the article aims at improving understanding of the boundary spanning practices related to these programs. The methodology is based on a case study investigating three doctoral education programs, all with close industrial engagement and strong focus in the solving of real-world industrial problems.

The results of the article reveal that the doctoral education programs can be an effective means to train boundary spanning capabilities to both industrial actors and academics. The most important factor behind this is motivation, since participating the education programs with a strong industrial engagement motivates the doctoral students and young doctors to seek opportunities to industrial working during or after their doctoral studies. A key indication of this is the fact that a clear majority of the participants of the programs continued their careers after doctoral graduation. For industrial actors, these programs gave opportunities to find effective ways of transferring newest academic knowledge to industrial domain through the mobility of skilled and motivated people, who also were able to bring fresh and innovative new ideas and mindsets to industrial R&D. This, in turn, clearly facilitates the commercialization of the university-based innovations developed in the doctoral training projects and related academic research.

4.4 Article 4: Involving customers and users in the commercialization of the results of university-industry collaboration

The research-based partnerships between industrial firms and academic institutions enable the firms to absorb new knowledge that may be critical to their product development activities, to find answers to their technical challenges, or to gain access to valuable capabilities or skills. However, to make the collaboration successful and effective, the firms must be able to commercialize the results of the joint development work. This has proved to be unexpectedly difficult, mainly due to the relatively high organizational barriers between universities and industrial firms.

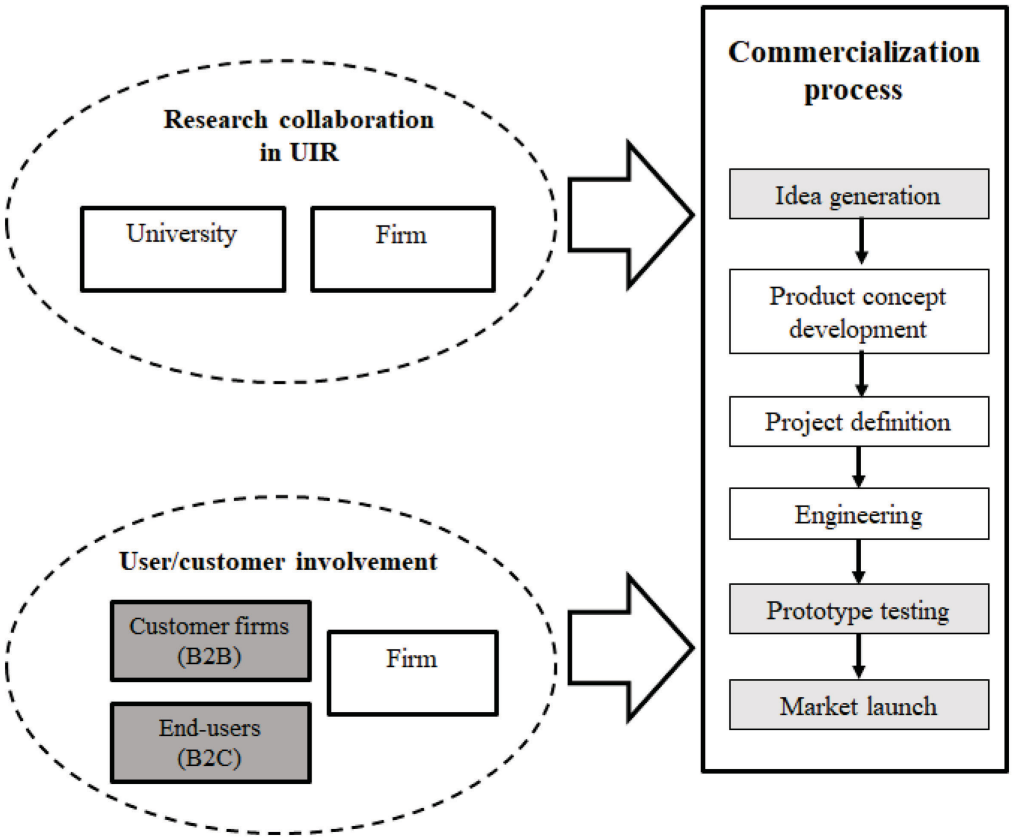

Figure 9. The role of customers and academics in R&D.

Article 4 focuses on the role of the users and customers in the UIR collaboration, particularly, in the commercialization of the UIR collaboration results. In the industrial R&D process (see Figure 9), the collaboration with universities typically takes place in in the early phases of the R&D process, namely idea generation and development. On the other hand, the customers and users are typically involved in the latest phases of the R&D process, in which the new innovations are very close to the market launch. The purpose of the Article 4 is to demonstrate how the involvement of customer and user insights in the university-industry collaborations can contribute to both early and late phases of the industrial R&D process, and in this way facilitate the commercialization of the results of university-industry collaboration. In this effort, the article intends to answer to the research question: ***Q4. What practices of customer and user involvement facilitate the commercialization of the results of the university-industry collaboration?*** Thus, the article examines the collaboration practices in the UIRs involving customers and users as key stakeholders. The research question is approached by means of a qualitative case study consisting of five UIR cases in Finland.

The results of the paper revealed that involving the users and customers in the UIR collaboration clearly facilitates the commercialization of the collaboration results. Involving the users and customers in the collaboration helps the partners to extend the focus of the joint development work also to the latest phases of the R&D process that are directly related to the commercialization, as presented in Figure 10. The first main finding of the article was that the interaction with the customers and users is able to produce valuable inputs for UIR-based development work in terms of the success of the commercialized new products. However, facilitating this interaction requires the university research team's multi-disciplinary capabilities, so that they are able to combine their academic knowledge with the understanding of the user behavior and customer relations. The second finding revealed that the role of users in UIR collaboration can contribute both early and late phases of the R&D process, whereas the customer involvement seems mainly to focus on the late phases of the process, as presented in Figure 10. As the third finding, the article states that the involvement of users and customers brings a clear added value to the UIR-based collaboration, especially in terms of commercialization.

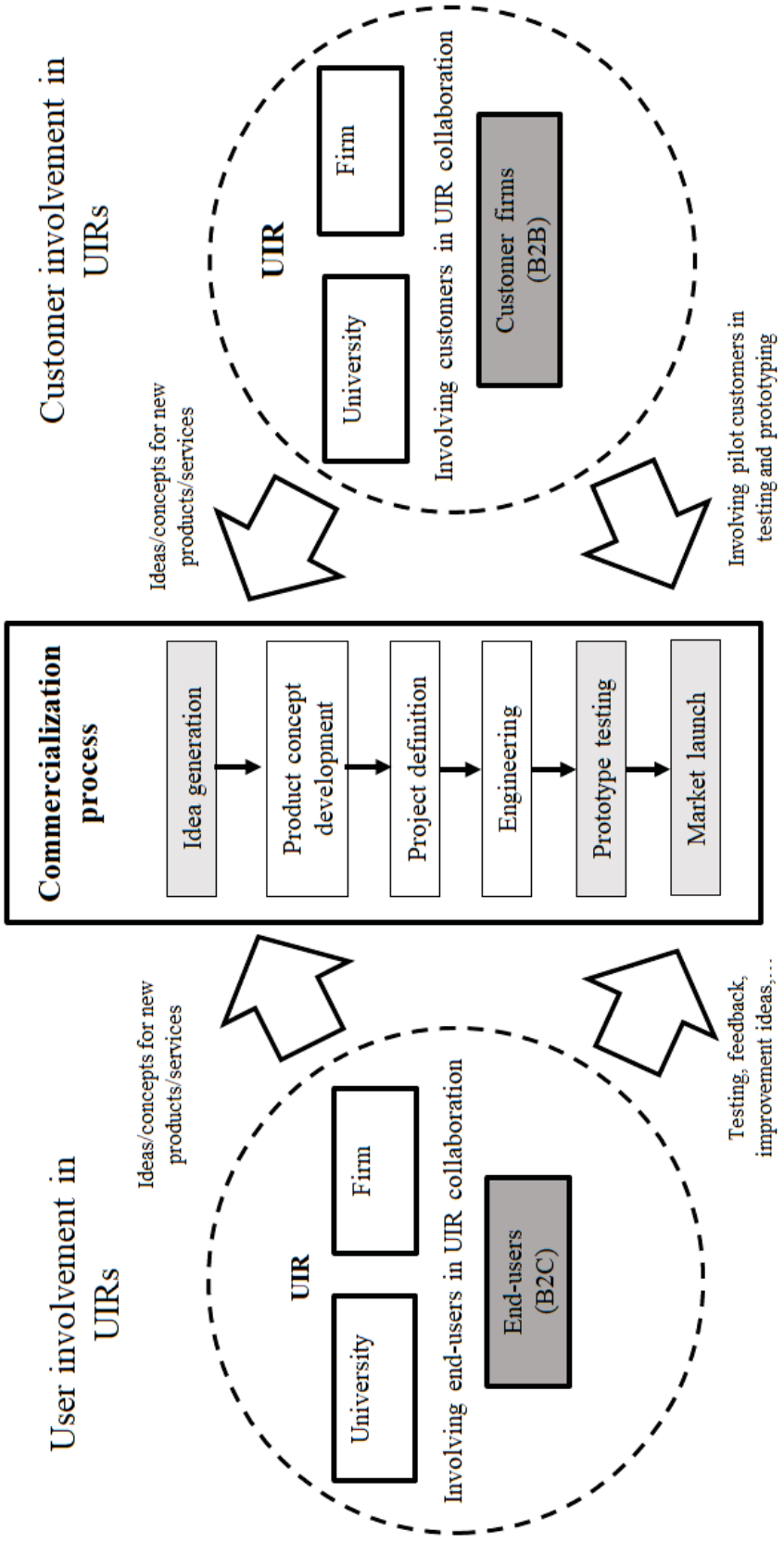

Figure 10. Involving users and customers in UIRs.

5 DISCUSSION

This dissertation intends to understand how partners learn and develop their mutual learning in innovative UIRs by answering the following research question: ***RQ. What kinds of collaborative practices facilitate learning in long-term university-industry relationships?*** As presented in the previous chapter, the main research question has been approached from different views in four articles. Each article makes a specific contribution based on its corresponding research question. The purpose of this chapter is to discuss the overall results of this dissertation, and present its contributions in terms of theoretical and practical implications. In addition, this chapter presents the limitations of the dissertation and briefly discusses directions for future research.

5.1 Theoretical contribution

Building on theories of relationship learning, this dissertation extends the existing, mainly quantitative, literature on university-industry collaboration by analyzing practices that can facilitate learning and joint knowledge creation in university-industry relationships. This is an essential research approach since UIRs tend to vary in terms of their learning capabilities, with some relationships producing higher innovative performance and learning outcomes than others. This is because these relationships have been capable of developing their own relation-specific learning mechanisms and practices (Selnes and Sallis, 2003, p. 80). For this reason, analysis of learning practices in UIRs is essential. This dissertation provides qualitative evidence of the practices through which UIR partners in long-term collaboration develop their mutual learning process and, in this manner, deepen their collaborative relationship. The main theoretical framework for the relationship learning process used in this dissertation comes from the work of Selnes and Sallis (2003). As explained earlier in this dissertation, Selnes and Sallis (2003) divide the process of relationship learning into three phases: 1) knowledge sharing, 2) joint sensemaking and 3) knowledge integration. In this section, the theoretical contributions of this dissertation are discussed in terms of these three phases.

Table 4. Different priorities for relationship learning among UIR partners

	TOPIC	ACADEMIC PRIORITY	INDUSTRIAL PRIORITY
KNOWLEDGE SHARING	**Enabling efficient knowledge transfer from university to industrial partner**	To provide relevant and reliable information and knowledge with a scientific basis	To obtain knowledge that can be utilized in the development of industrial innovations
	Enabling efficient information transfer from industrial partner to university	To obtain relevant and practical state-of-the-art knowledge about the problem to be solved	To protect the company's confidential and commercially sensitive information
JOINT SENSEMAKING	**Differences in motives, actions and organizational cultures between partners**	University researchers' incentives are mainly based on publication records	Success of industrial R&D is mainly based on innovation performance and competitive advantage facilitated by new product success
	Developing knowledge resources and competences in the relationship	To utilize the created knowledge and joint research in publications, education and/or researcher training	To transfer valuable competences and knowledge resources to industry
KNOWLEDGE INT.	**Practical utilization of new knowledge created by joint research**	To support the industrial partner in knowledge utilization	To commercially utilize the new knowledge
	Publishing the results of the research	To publish results of scientific significance	To keep results secret to maintain a competitive advantage

Following the main research question, the main contribution of this dissertation is analysis of collaborative practices that facilitate relationship learning and joint knowledge creation in long-term UIRs, as summarized in Figure 11. All four articles approach this same question from different viewpoints and identify collaboration practices related to them. However, it is important to understand that collaboration practices cannot be fully analyzed without understanding the barriers that might prevent collaboration from taking place in UIRs. Barriers coming from partners' organizational cultures, attitudes and norms (as well as clearly different motivations for collaboration) cause challenges for collaboration and relationship learning. This topic is present in all four articles, and their impact has been analyzed in the context of each article. Table 4 presents a summary of the academic and industrial priorities for collaboration.

The analysis presented in the four articles of this dissertation reveals that partners can develop practices that facilitate joint innovation through relationship learning, as presented in Table 5. In the first part of relationship learning (knowledge sharing), partners share their knowledge and information in the relationship. The role of knowledge, particularly knowledge transfer in UIRs, belongs to the focus area of Article 1. The results presented in Article 1 are relatively consistent with earlier research, which suggests that the main enablers of knowledge sharing between partners include long-term experience in terms of the collaboration and good personal relationships between actors on both sides of the relationship. In this, the role of boundary actors, bridging industry and academia, is emphasized (Article 3). As shown in Articles 2 and 3, universities are able to facilitate boundary spanning activities by means of different kinds of educational activities, such as courses, project work and post-graduate courses. As demonstrated in Article 1, one of the main barriers to efficient knowledge transfer from industry to academia is the level of openness concerning commercially sensitive industrial knowledge, with empirical data emphasizing the role of mutual trust between partners, which can stimulate rich informational exchange and the sharing of valuable knowledge. High levels of trust in relationships enable industrial partners to disclose sensitive information, which may be commercially advantageous but necessary in order for research partners to carry out relevant research. Observations have revealed that long-term and close personal interactions between key stakeholders in relationships are the most important factors facilitating creation of mutual trust, also facilitating commitment between partners. Commitment, in turn, positively impacts on the partners' adaptation to each other's processes and way of working.

Table 5. A summary of practices facilitating relationship learning

	ACADEMIA	INDUSTRY	JOINT ACTIONS
KNOWLEDGE SHARING	Allocating relevant and competent researchers who may also have industrial experience of the collaboration project	Allocating relevant and competent R&D staff to the collaboration project	Developing different kinds of formal and informal interaction between partners
	Aiming for close collaboration and regular face-to-face contact with industrial partners	Improving understanding of academic research and ways of working	Aiming for long-term collaboration in which personal relationships and trust are developed between partners
JOINT SENSEMAKING	Business orientation and understanding of the industrial way of working Understanding the value of industrial collaboration in terms of e.g. research funding, practical research	Providing incentives to university researchers working on joint projects Promoting the results of university collaboration within the industrial organization	Jointly finding ways of rewarding, based on results achieved in joint projects
	Taking an active role in project management Involving different hierarchical levels of the university's organization in the collaboration	Involving different organizational units in collaboration Involving different parts and levels of the organization in the collaboration	Developing collaboration practices at different organizational levels
	Providing the partner with opportunities to participate in education and student projects Providing the partner with training and other forms of tailored education	Providing university researchers with opportunities, e.g., industrial training and practice	Jointly finding forms of collaboration in, e.g., student projects, training and education

KNOWLEDGE INTEGRATION	Implementing and documenting results in a form that is easy to implement by the firm's internal R&D	Providing the university partner with R&D equipment for implementation and testing	Sharing and jointly developing a technical infrastructure for implementation and testing
	Creating and supporting the prototyping process	Internally marketing the results of joint research	Creating demonstrations and prototypes in collaboration
	Creating a research agenda that is not controversial in terms of industrial targets but can provide potential topics for publication	Actively finding opportunities for publishing selected results of joint research	Jointly finding areas in which it is possible to publish the results of research
			Writing joint publications, with academics and industrial actors jointly authoring papers

In the second phase, joint sensemaking is a central factor, facilitating efficient joint knowledge creation between industry and academia, and lowering organizational barriers related to different motives, actions and organizational cultures between partners. As discussed in Article 1, the actors involved have totally different incentive systems and, therefore, need to develop collaborative settings that are motivating for both sides of the relationship. For example, partners may stimulate collaboration by developing industrial partners' incentive systems so that they also include university staff working on joint projects, thereby promoting university collaboration within their own organizations. It is equally important to motivate academic involvement in industrial collaboration by motivating academics to be business-oriented and understand the industrial way of working in order to adapt to their partners' processes. In this context, the role of boundary actors is again emphasized. As presented in Article 3, universities may facilitate academic engagement in the industrial world by, e.g., developing joint doctoral education with industrial partners. This improves academics' industrial understanding and helps them to cross the boundary between academia and industry. On the other hand, Article 2 illustrates the educational practices related to, e.g., joint courses, training and student projects organized in collaboration with industrial partners, which may facilitate and deepen collaboration and knowledge creation. All these collaborative practices develop both partners' capabilities for boundary spanning, which in turn may enable academics and their industrial collaborators to converge

in terms of attitudes and arrive at a mutual understanding about the research process and collaboration practices.

The third phase, knowledge integration, refers to utilization of the knowledge jointly created in a UIR. For companies, the main motivation behind their collaboration with universities is to commercialize university-based technologies for financial gain. Therefore, as explained in Article 4, understanding the industrial commercialization process is also very important to academics when engaging in industrial collaboration. To commercialize results, an industrial partner often needs to undertake internal marketing to promote results within its own organization. For this, industrial managers need to have concrete examples of the research results, such as prototypes. Therefore, it is important for academics to be able to participate in industrial implementation of research results. In many cases, this requires that academic researchers cross the boundary between academia and industry, and participate in the industrial product development process. These kinds of boundary spanning practices (related to industrial utilization of the research results) have been presented as outcomes of all four articles. As indicated in Article 4, commercialization of UIRs may be facilitated by involving users and customers of the industrial actor in joint development work. Customer and user insights can be combined with academic knowledge in UIR-based collaboration, which, in turn, helps UIR partners utilize their understanding of customer and user experiences in the commercialization of new products or services developed through UIR collaboration. Article 1 focuses on one of the most important obstacles in joint utilization of the results of UIR collaboration: the openness of research results. Previous research has shown that different interests related to the openness of research results may often lead to conflicts between partners about the openness of results and publication policy in collaborative research between academia and industry. The reason behind this is the fact that companies wish to keep results secret from their competitors, whereas academic researchers prefer the production of open knowledge in order to make their research results public in scientific forums. However, the results of Article 1 reveal that UIR partners may be able to reach a consensus on the publication policy through negotiation and mutual understanding, and jointly develop practices to overcome this obstacle. Moreover, Article 1 shows that publishing results together with industrial actors provides academics with an attractive way of publishing research results, linked to real-world applications, which in turn can deepen the UIR relationship.

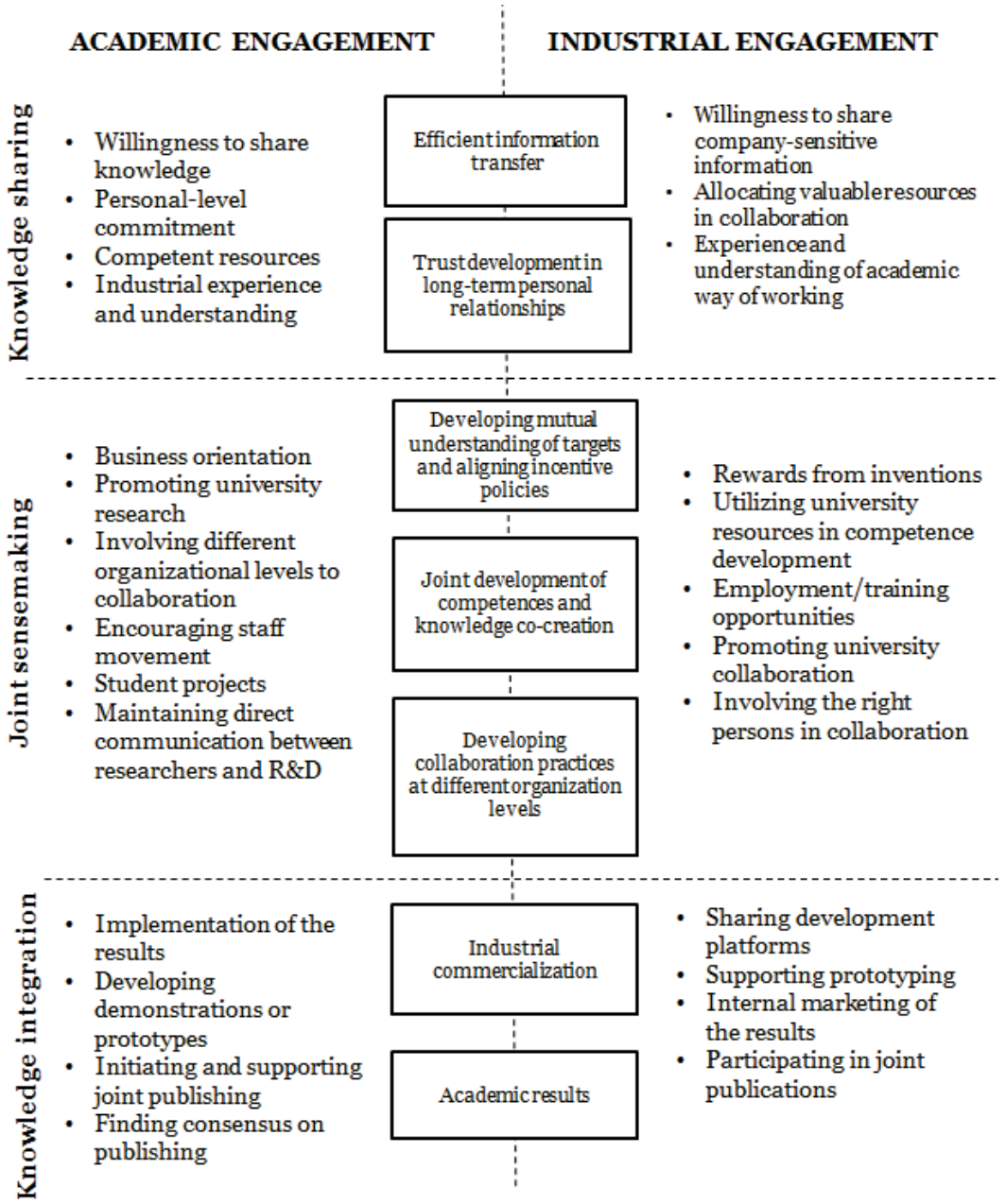

Figure 11. A summary of the identified learning practices

5.2 Practical implications

Acquiring new and valuable practical knowledge to enhance the results of industrial R&D is a central challenge for technology firms. To stay ahead of their competitors in terms of R&D performance and innovativeness, firms need to find new knowledge of interest and value from external sources. For this reason, industrial firms are nowadays increasingly extending their R&D capabilities and

resources through networked collaboration with academic institutions. This trend has greatly facilitated growth of collaborative relationships between academia and industry, with firms operating in technology-intensive areas, in particular, increasingly utilizing and absorbing the results of academic research through collaborative university-industry relationships. As UIRs enable firms to obtain knowledge, competences, skills and capabilities that may have a critical impact on their innovation performance and R&D outcomes, technology firms increasingly seek guidance on "best practices" related to the establishment and management of sustainable university collaboration. Firms need an understanding of strategies and incentives as well as measuring and monitoring of the outputs of collaboration, and also require the capability to absorb new knowledge available in UIRs. However, to fully utilize the intended results of UIR collaborations, firms must be capable of commercializing the results of joint co-creation conducted within UIRs. In many cases, this utilization of results has proved to be a challenge for both industrial and academic actors. One of the main reasons for difficulties related to commercialization of UIR collaboration results may be the existence of organizational barriers between academia and industry. Whereas private companies focus on industrial utilization of collaboration results in the short-term, academic institutions primarily focus on creating and publishing open knowledge and providing education. The purpose of this dissertation is to understand how industrial actors and academics can facilitate efficient mutual learning in UIRs. By analyzing practices in the mutual learning process, the dissertation also studies how partners in long-term UIRs are able to deepen their collaborative relationship and develop new ways of interaction. The dissertation also aims to extend understanding concerning the role of informational organizational barriers in UIRs, and seeks to identify practices that help partners overcome these barriers.

The findings of the dissertation provide a rich set of collaborative practices and mechanisms that can help both university and industrial partners to converge in attitudes and create a mutual understanding of the collaborative research process. The key findings of the dissertation highlight the role of mutual trust, personal-level relationships, mutual adaptation and reaching a consensus during utilization of the results of UIR collaboration. The results highlight the importance of involving different stakeholders (such as university students and the customers of industrial partners) in UIR collaboration to facilitate the commercialization of UIR innovations. Furthermore, educational collaboration (in terms of jointly organized courses, student projects and thesis work) has proved to be an efficient way of facilitating the mutual learning process taking place in UIRs. In this context, the importance of boundary actors as a bridge between academia and industry is emphasized. In this manner, the identified practices help partners overcome the barriers to collaboration and establish an efficient learning relationship.

5.3 Limitations and future research suggestions

Understanding the facilitation practices of relationship learning and joint knowledge creation is important in research related to university-industry collaboration. As with any research, this dissertation has limitations, which may suggest avenues for future research. One of the main limitations comes from selection of the research approach. To understand the practices of learning and collaboration in UIRs, a qualitative case study approach has been used. However, as the case study method does not fully permit generalization of the results, future studies of a quantitative nature could be used to test the outcomes of this dissertation with a larger set of data. For example, the dependences between educational activities or user involvement and UIR performance could be topics for quantitative research. The role of joint publications between university and industry actors could also be utilized as a measurable outcome of UIR collaboration in a quantitative analysis.

This dissertation has analyzed practices and mechanisms collected from successful UIR case studies in Finland. Although focusing on successful cases may provide the best possible information on practices that sustain UIR-based collaboration over the years, it might also have been beneficial to consider those relationships that have not been successful. Although many of the respondents also reflected on experiences from unsuccessful collaborations in the case interviews, only focusing on successful cases may lead to underestimation of the importance of obstacles or, alternatively, overestimation of the enablers of learning. For this reason, focusing only on successful cases may be one of the limitations of this dissertation, and forthcoming case studies could also analyze unsuccessful cases to better understand the factors that may impair relational learning in UIRs. Another limitation of this dissertation is the inevitable fact that all the cases inspected are from Finnish UIRs. Even though analysis of these relationships has provided a rich set of learning practices, involving UIR cases from different parts of the world might have been interesting, enabling comparisons between countries. In a similar manner, the cases used in this dissertation come from the technology industry, with an emphasis on the IT domain. Involving cases from other industrial areas might have elicited additional information and created new insights into learning practices. Thus, a promising avenue for future research could be studying relationships in different geographical areas or areas of industry. In this manner, generalization of the results might have needed additional cases in other research settings.

5.4 Conclusions

University-industry collaboration does not only combine heterogeneous knowledge but also heterogeneous partners. Due to this heterogeneity, partners do not only have to develop practices that facilitate the learning process in their relationship, but they must also learn to collaborate with each other. In this manner, UIR actors need to learn how to overcome organizational barriers caused by different orientations, cultures, attitudes and incentives. The results of this dissertation show that establishing and maintaining a successful learning relationship between industry and academia requires long-term investment, understanding and adaptation from both parties of the relationship. This is possible only when partners can develop mutual trust, facilitated by personal-level professional relationships and close interactions within the relationship. To make this happen, the role of boundary spanning capabilities is emphasized. Boundary actors who have developed the capability to cross the boundary between industry and academia are key to creating and developing personal and professional interactions across this boundary. Inter-organizational trust, facilitated by these interactions, is necessary to create the right atmosphere in which partners can jointly create and utilize valuable new knowledge, overcoming organizational barriers to collaboration.

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190

Balancing learning and knowledge protection in university-industry collaborations

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Abstract

Purpose – The purpose of this study is to examine the tension between learning and protection in university-industry relationships (UIRs) and, in particular, to identify practices that facilitate ways of coping with this tension.

Design/methodology/approach – The empirical work for the study is based on a qualitative comparative case analysis of six successful, long-term relationships between industrial technology firms and university research groups in Finland.

Findings – The findings of the study reveal that the development of mutual trust, based on personal-level relationships, adaptation and reaching a consensus about the utilization of research results represent the key processes that enable partners to balance learning and protection and lower the informational barriers within the collaboration.

Research limitations/implications – The case data have been collected from IT industry, in which the need for knowledge is changing rapidly and the need for learning is typically high. However, generalization of the results may need additional case studies including from other industrial areas.

Practical implications – The results highlight a rich set of practices that can support both industrial actors and academics in improving their engagement in collaboration and to facilitate successful knowledge creation and utilization in UIRs.

Originality/value – This study extends the existing literature on UIR learning by presenting organizational practices, which help UIR actors to balance learning and protection in their collaboration. Along with mutual trust and adaptation achieved in long-term personal relationships, these practices allow partners to overcome organizational barriers that result from different orientations, attitudes and incentives.

Keywords University-industry collaboration, Learning paradox, Relational learning

Paper type Research paper

1. Introduction

The growing interest in university-industry relationships (UIRs) among high-technology firms is based on the view that collaborative research between academia and industry can be a powerful source of innovation (Perkmann *et al.*, 2013; Ankrah and Al-tabbaa, 2015). During recent years, the aspects of joint knowledge creation and learning in UIRs have received growing attention among scholars (Weckowska, 2015; Kunttu, 2017). Previous research has shown that knowledge sharing and transfer taking place in UIRs enable industrial firms to absorb knowledge that may be critical to their future innovations and

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new product development, as well as for solving technological problems and gaining access to critical human resources and new competencies (Siegel *et al.*, 2004; Lee, 2011). However, the UIRs are usually mediated by relatively high organizational and cultural barriers. One of the core barriers to knowledge transfer and creation between universities and industry involves different institutional norms concerning private and public knowledge and information (Bruneel *et al.*, 2010). In universities, the creation and development of public and open knowledge are central principles (Lee, 2011), whereas the economic value of knowledge, which can be assessed according to the potential competitive advantages that it facilitates, represents a key factor affecting industry actors' attitudes to knowledge and the openness shown towards it in private companies (Geuna and Nesta, 2006). For this reason, the actors working in UIRs are increasingly facing the dilemma of how to enable learning and access to scientific knowledge provided by the UIRs, whilst simultaneously protecting their own valuable knowledge resources, which may have strategic value in terms of competitive advantage. In this manner, the competing demands between learning and protecting in the relationship have led to the challenging task of managing the balance between "trying to learn and trying to protect" (Kale *et al.*, 2000).

As most of the existing research on UIR learning is quantitative in nature, concentrating on, for example, the determinants of innovation performance, barriers to collaboration (Bruneel *et al.*, 2010), development of mutual trust (Bstieler *et al.*, 2017), or relationship governance, the existing research falls short in its analysis of the practices of learning in dyadic university-industry collaborations. Moreover, previous research provides minimal information about the practices and mechanisms behind learning processes that occur in the research-based interactions between universities and industry. Indeed, Weckowska (2015) has studied UIR learning mechanisms and Bruneel *et al.* (2010) have examined the practices that may lower the organizational and informational barriers in UIRs. However, research on relational practices facilitating UIR learning remains absent. Coping with the competing demands between learning and protection, in particular, seems to be a neglected topic in the existing UIR research, despite partners' attitudes towards knowledge sharing and openness towards knowledge potentially imposing a real informational barrier to UIR learning (Bruneel *et al.*, 2010).

To fill this gap, this study intends to answer the following research question:

RQ1. What practices help industrial firms to achieve a balance between learning and knowledge protection in UIRs?

To address this question, our aim is to study the tension between learning and protection in UIRs and, in particular, to identify the practices that facilitate coping with this tension. Thus, our objective is to find organizational mechanisms and practices that help the actors in UIRs to facilitate effective relationship learning and joint knowledge creation processes while simultaneously maintaining the confidentiality of that knowledge. This study makes an empirical contribution to the existing, mainly quantitative, literature on UIR learning by examining the relational level practices in terms of a qualitative multiple case analysis. The study also extends the existing literature concerning informational barriers to learning in UIRs by presenting relational practices, which may significantly lower these barriers to collaboration. These findings may have also significant managerial interest, given that most high-technology companies utilize collaborative university partnerships for their innovation and product development work, and thus face the challenge of learning and protection.

2. Theoretical framework

Organizing raises multiple tensions, which are often contradictory in nature. Whereas the more conventional contingency theory relies on either-or decisions by finding the most

suitable fit for each situation and prioritizing competing tensions, the more recent paradox theories suggest a "both-and" approach, which could foster novelty, creativity and long-term sustainability (Smith and Lewis, 2011). Thus, a paradox perspective argues that long-term sustainability requires the organization to undertake continuous efforts to meet multiple and divergent demands simultaneously (Smith and Lewis, 2011). In this "both-and" thinking, the organizational actors develop practices and mechanisms through which they can cope with the conflicting demands and find a balance between them (Jay, 2013). The collaborative relationships between industrial firms and universities can be seen as learning alliances, in which the partners strive to learn or internalize critical information or capabilities from each other (Kale *et al.*, 2000). In these kinds of relationships, the firms continuously face competing demands about sharing critical knowledge with the research partner to facilitate the research process, while, on the other hand, managing the risk of losing knowledge that may be commercially sensitive (Geuna and Nesta, 2006). To find a balance between these conflicting demands about learning and protecting knowledge in a UIR collaboration, the partners have to develop the practices of their mutual learning process to facilitate effective learning process and simultaneously take care of protecting commercially sensitive information.

This research studies the learning practices that may help the UIR collaborators cope with the competing demands by overcoming the barriers to collaboration. The learning process is analyzed using the theoretical framework of relationship learning (Selnes and Sallis, 2003). The work of Selnes and Sallis (2003, p. 80) defines relationship learning as a joint activity between a supplier and customer where two parties share information, which is then jointly interpreted and integrated into a shared relationship-domain-specific memory that changes the range or likelihood of potential relationship-domain-specific behavior. The first phase, knowledge sharing, refers to knowledge transfer in terms of formal and informal interaction within the relationship. The main knowledge-based obstacles in effective knowledge transfer in UIRs include the sharing of commercially sensitive industrial information with the academic partner (Bruneel *et al.*, 2010). Sharing industrial information may be critical for the academic partner to properly accomplish the research task but, at the same time, this information may be commercially sensitive for the industrial partner. For this reason, finding the balance between knowledge sharing needs and the need to protect the sensitive information (Kale *et al.*, 2000) is central for the UIR actors (Geuna and Nesta, 2006). The second phase of the relationship learning process is related to joint knowledge creation through the process of joint sense-making (Selnes and Sallis, 2003). In this phase, the partners jointly create new, experience-based tacit knowledge that is difficult to imitate or transfer outside of the relationship and combining their own previous knowledge resources and experience. One of the major obstacles to joint sense-making in UIRs is a consequence of the differing orientations of industry and universities (Siegel *et al.*, 2004), which are visible in the motives, attitudes and organizational cultures of these institutions. Whereas the main motive of industrial actors is to create and develop private knowledge that should remain hidden within the firm or disclosed in a limited way through patenting (Geuna and Nesta, 2006), the main motive among academics is to create reliable, public knowledge. Thus, conflicting attitudes and motives concerning the joint knowledge creation process have a particular impact on the joint learning process, whereby the partners must find ways to cope with this tension in UIR collaborations. In the third phase of the learning process, the organizations develop relationship-specific memory structures within which they jointly develop relationship-specific knowledge that can be stored and integrated. In this phase, the partners may implement the results of their joint development and learning as concrete outcomes that can be utilized in industrial commercialization processes or as academic outcomes. In UIRs, the industrial partners have a clear need to protect the results

of the co-creation, as they may be sensitive in terms of competitive advantage. On the other hand, academics have an interest in publishing the results from their joint actions on industrial projects as establishing a good reputation through publications and other academic credentials is critical to career success and sustainability in universities (Bruneel *et al.*, 2010); in other words, there is a need for a process that makes the jointly created knowledge accessible to academic audiences.

3. Methodology

In this study, an explorative qualitative in-depth case study approach is used to examine six UIRs in Finland (Table 1). As the case study approach has been found to be particularly useful when studying complex and evolving relationships and network interactions in real-life contexts (Easton, 2010), it was selected as the research method in this paper. The cases represented UIRs in the field of the information technology (IT) industry (electronics, mobile communications and software). Knowledge creation and application are seen as important in high-technology sectors, and the need for learning is typically particularly high in the IT industry, in which knowledge changes quickly. According to Yin (2009), multiple sources of evidence should be used in qualitative data collection. Therefore, the case data collected include interviews, as well as secondary data, such as corporate brochures and archives, Internet information, publications and descriptions of the partnership. The cases for the study were selected purposively, rather than randomly drawing on the concept of the information-rich case (Welsh *et al.*, 2008). To select cases and recruit interview participants for our semi-structured case interviews, we used different network platforms and personal contacts to identify cases, in which a long-term and close collaborative UIR has yielded to successful results in terms of practical value for the industrial partner.

The data used in this case study were collected over a period of seven months. The researchers put significant effort into accessing those industrial managers who had the best possible long-term experience from collaboration with their university partner in the selected cases. For the case interviews, a semi-structured interview template was designed. The template focused on the major parts of relationship learning: knowledge sharing, joint sense-making and storing knowledge within the relationship-specific memory in the context of UIRs. In each of the three parts, the template included questions on the practices and factors related to the joint learning process, such as:

Q1. How would you describe the information sharing within your relationship? or Based on your experience, which factors can facilitate open discussion and information sharing between you and your partner in your relationship?

The template also included several questions concentrating on learning and protection of knowledge, such as:

Q2. Do you consider that the partners' different motives concerning the utilization of jointly created research results cause conflicts in the relationship?

The interview questions were designed in a way that encouraged the interviewees to relate their own experiences about UIR learning practices and how they had coped with the competing tensions of learning and protection:

Q3. Do you think that treating company-specific information confidentially has been an obstacle in your collaboration and can you provide examples on these kinds of situations?

Table I. Case descriptions for the studied relationships between universities and industrial partners

Description	Relationship A	Relationship B	Relationship C	Relationship D	Relationship E	Relationship F
Number of employees in R&D unit	90	120	50	80	200	150
Main products/services of the customer company	Electronic and electrical systems	Mobile devices	Software products	Software for mobile devices	Hardware platforms and embedded software	Power electronics products
Relationship						
Duration of the relationship	Four years	Five years	Four years	Five years	Five years	13 years
Area of the joint development project(s)	Process development for R&D function	Software and algorithm development	Software and algorithm development	Algorithm development	Software development	Hardware and related embedded software development
Key facilitators of the relational learning process (as evaluated by the customer)	Very close collaboration with and the university partner's good understanding of the industry facilitate learning in the relationship	The university partner has been developing new technologies for the industrial partner; the partner actively proposes new ideas in joint projects	The university partner acquires new knowledge and shares it actively with the industrial partner; it also proactively prototypes new ideas for the customer	The university partner has strong competences and experience in the relevant field, which also makes it competent in terms of solving complicated technological problems in collaboration with company R&D staff	The university partner has very strong competences in the relevant field, as well as being able to put forward good proposals that could improve the quality and competitiveness of the customer's products	The university partner has considerable experience of the customer's technology area; close personal relationships between researchers and the company's internal R&D staff help the developers to develop new ideas together

(*continued*)

Table I.

Description	Relationship A	Relationship B	Relationship C	Relationship D	Relationship E	Relationship F
Key industrial results of the joint research projects	New processes and tools for the development of the R&D organization	New software algorithms commercialized as new features in customer products	New software algorithms developed together, some of which have been commercialized	New software algorithms developed together	New software algorithms developed together, part of which are now in the process of commercialization	The results of several joint projects have been commercialized in the customer's products
Key academic results of the joint research projects	Scientific articles, educational collaboration	Several scientific articles (also jointly authored) and Master's theses; jointly organized education	Scientific articles	Several scientific articles and Master's theses; jointly organized education	Scientific articles	Several PhD and Master's theses, as well as scientific articles
Participants in the case interview (company)	R&D director	Research manager	Project manager	Technology manager	R&D manager	Senior director, global innovation
Participants in the case interview (university)	Assistant professor (responsible researcher)	Professor (leader of research group)	Professor (leader of research group)	Professor (leader of research group)	Professor (leader of research group)	Professor (leader of research group)

By posing these kinds of questions, the researchers aimed at initiating free discussion on the interviewees' experiences and views on various parts of relationship learning in UIRs. Each of the case interviews involved an interviewee on both sides of each case relationship to involve relevant interviewees from both sides of the relationship to validate the analysis. The interviewed industrial managers named their key collaborators on the university side, who were usually the leaders of research groups. Interviews, which generally lasted between 60 and 90 min, were recorded and transcribed. To maintain confidentiality of the interview data, the analysis presented in this paper identifies the interviewees only by position (university = UNIV; industry = IND). Given that the collected interview data reflected the interviewees' own personal views on the relationships studied, the researchers actively monitored and discussed issues raised during the interview process by comparing the answers from both sides of the relationship and asking additional questions. The researchers also cross-checked each other's independent interpretations after every interview.

4. Case analysis

In this section, the data collected from the case-specific interviews is analyzed to identify differences and similarities in the data. Relationship learning related to UIRs is analyzed in terms of knowledge sharing, joint sense-making and the integration of knowledge into relation-specific memory.

4.1. Practices of knowledge sharing

In the literature on organizational knowledge flows, knowledge accessibility is regarded as a driver of innovation in the relationships between organizations (Tsai, 2001). As described earlier, one of the main barriers to knowledge transfer in UIRs is related to the conflicting norms concerning private and public knowledge and information (Bruneel *et al.*, 2010). The industrial interviewees had very coherent views on the protection of the commercially sensitive information:

> The university actors have to understand that the great part of the knowledge we are sharing is commercially sensitive. (IND F)

> It is a rule that all the collaboration is made under a non-disclosure agreement, and if there is some information that can be openly published, it is always reviewed by us. (IND B)

However, when the industrial actors were asked how they cope with the conflicting demands of information sharing and protection, they usually talked about long-term collaboration, personal relationships and the building of trust. Interorganizational learning is typically based on close personal-level relationships, in which substantial knowledge exchange, and hence effective learning activities, can occur and be sustained between partners (Fang *et al.*, 2011; Bäck and Kohtamäki, 2016) to move knowledge from academia to industry, which is a process that requires engagement from both parties (Perkmann *et al.*, 2013). Our interview data were consistent with this statement, as practically all the interviewees suggested that long-term personal relationships are the key enablers of efficient knowledge transfer:

> As our collaboration has lasted several years, we know each other very well, and we speak the same language. Hence, our university partner knows our problem area as well as our technical limitations. This way, it is easy to go directly to the issues to be solved. (IND C)

> I feel that long-term personal relationships between the industrial partner's R&D staff and our researchers represent one of the most critical facilitators of close collaboration and open communication in this relationship. (UNIV D)

Thus, in long-term collaboration, both parties learn from experience and, together, develop richer and more refined ways to engage with their research partners (Bruneel *et al.*, 2010). Collaborative experience especially plays a critical role, as research institutes, which already have experience of industrial collaboration, tend to be called on by their industry partners in the future (Perkmann *et al.*, 2013):

> We have had a research collaboration with this partner for several years. This is of remarkable benefit in terms of information sharing. (UNIV C)

Mutual trust between partners is essential in facilitating UIRs (Santoro and Saparito, 2003) because the firms often need to share commercially sensitive information and tacit knowledge with their university partners. Thus, high levels of trust between university and firm stimulate rich information exchange and the sharing of valuable knowledge and information (Santoro and Saparito, 2003; Inkpen and Tsang, 2005). Moreover, as it is often very difficult to specify the actual results and implications of research, the research process between firm and university is beset with many unknowns (Bruneel *et al.*, 2010), as well as possible fears of opportunistic behavior on the part of the other party. A high level of trust in the relationship, however, is able to reduce this fear and also resolve any problems that may arise in the relationship (Inkpen and Tsang, 2005), given that mutual trust allows partners to be confident that the other party is treating them fairly and in a consistent manner (Bruneel *et al.*, 2010):

> Knowing the university partners at a personal level and the long-term experience of working with them help us to trust them. (IND D)

> We have provided the university with a lot of our internal R&D tools and knowledge. This was necessary to enable efficient and fruitful research. Of course, this was somewhat risky for us in the beginning, but there was no other way to proceed than to trust them if we wanted good results. So we had to open our doors to the university. Everything has gone well and the trust is now at a very high level. (IND F)

> I have a high level of personal trust for our university partners. However, due to our corporate policy and rules, I cannot disclose as much information to them as I would like to. This is a pity, since I know that the researchers would be more motivated if they did not need to work "in the dark". (IND C)

Thus, high-level trust enables partners to work efficiently and collaboratively to solve problems, which in turn lowers the barriers to knowledge transfer (Siegel *et al.*, 2004; Bruneel *et al.*, 2010).

4.2 Practices of knowledge creation in joint sense-making

The process of searching for a common understanding and for the joint interpretation of the information and knowledge created in the course of joint action between partners is called joint sense-making (Selnes and Sallis, 2003). As such, it can be regarded as a link between information and its meanings (Fang *et al.*, 2011). As described earlier, one of the major barriers to advancing joint activities and knowledge transfer in UIRs is the difference in the orientations of industry and universities. These differing orientations

can be seen in motives, attitudes and organizational cultures, all of which have a particular effect on the interaction in UIRs (Siegel *et al.*, 2004). Again, the academic priorities conflict with the industrial priorities, especially in terms of the openness of knowledge:

> Based on my experience, some research groups are not eager to collaborate with industry even if their research areas might have potential for commercialization – they feel that it is more important to concentrate on publishing in high-quality journals. (IND D)

> It is true that universities usually encourage their researchers to publish at a high level, and this does not necessarily fit well with practical research collaborations with industry. (UNIV A)

Great differences in the views on the openness of knowledge may indicate weak attitudinal alignment in the collaboration among academics (Bruneel *et al.*, 2010), as their possibilities to publish the research results may be limited in the industrial projects. This, in turn, may impair the process of joint learning and knowledge creation. Moreover, collaboration partners in firm-university collaboration have totally different incentive systems (Bruneel *et al.*, 2010; Lee, 2011), as the academics are typically rewarded based on their publication records, whereas the industrial actors' incentives are mainly dependent on product development outcomes. These differences can make the search for a common understanding and setting common targets very difficult. However, our data reveal that the partners can also carry out concrete actions to develop the incentive policies in a ways that encourage the actors to UIR collaboration:

> In the very early stage of our collaboration with our university partner, we made a decision that we would extend our internal R&D incentive system to also cover the university researchers working on our joint projects. (IND F)

> The fact that the company covers our researchers with its incentive system is an honor to us and motivated our research staff to develop and report inventions in the project, even if the researchers cannot improve our publication records in this industrial project. (UNIV F)

In Case F, the industrial partner decided that the university researchers working in the collaborative projects with the company were granted the same incentives for inventions and patents that the company grants to its own R&D staff. Therefore, the company encouraged the university research staff to make inventions and report for them in the same manner as the company internal staff. According to the interview data, this kind of setting facilitates joint efforts in knowledge creation and learning, which also yield concrete industrial outcomes in the research projects. In the same manner, the university partner may also develop their own incentive policy to encourage the research staff to industrial collaboration, as described in Case A:

> In addition to the traditional publication record-based incentive system, our university also rewards those researchers who take an active role in establishing and running projects with industry. (UNIV A)

The interview data also emphasized the fact that industrial managers who have a background in university research are open to collaboration with universities and often steer such collaborative projects:

> It is usual that our R&D managers are graduates of the university that is our research partner. For this reason, they have close relationships with university people and they are very open towards collaboration. (IND E)

> I have been studying and also working in the past in the university with whom we now collaborate. Also many of my colleagues come from there. Therefore the link with them is quite natural. (IND C)

Thus, the data highlight the importance of boundary actors, who operate across organizational boundaries between university and industry, and also demonstrate an important practice related to boundary spanning activities (Siegel *et al.*, 2004; Kunttu *et al.*, 2018), in which the industrial partner recruits former university research staff who have previous experience of industrial collaboration.

> Before I joined this company, I worked for several years as a university researcher and completed my PhD in the same area as I am now working in industry. Therefore, I understand how researchers work in universities and what kinds of task are beneficial to give them as research projects. I also have good relationships with several research groups working in my field. (IND B)

The movement of staff also occurs in the opposite direction:

> Even though I have a background in research, I worked for several years in industry before returning to my current position in the university. I feel that this is a very good experience in terms of helping me better manage our industrial relations. (UNIV A)

4.3 Practices of knowledge integration

The third part of a relationship learning process involves the integration of jointly developed knowledge in relationship-specific memory (Selnes and Sallis, 2003). This part is often referred as knowledge implementation or institutionalization. In this process of implementation of the jointly created knowledge, the partners face conflicting demands of the disclosure the research results. It is very important for the industrial partner that it is able to utilize the results obtained in the collaboration with external research partners within its own organization, and develop them towards commercialization. In this process, they must be able to show concrete results:

> A new innovative method developed with the university never ends up in the productization pipeline unless we can show that it really works. For this, we must build some kind of proof of concept, which can be used when I show the results to decision makers in our organization. (IND B)

The interview data showed that the academics are able to support the industrial partner in this process by developing prototypes or demonstrations together with industrial developers:

> We usually make a pilot project using real circumstances. My experience has shown that a working pilot opens many doors in the company. (UNIV A)

The industrial integration and utilization of experience-based tacit knowledge, obtained and accumulated in joint action between academic research and industrial R&D, typically require personal efforts on the part of all the key stakeholders in the projects. In practice, this means that the persons who have created the knowledge also need to take an active role in its integration and utilization (Bäck and Kohtamäki, 2016). The industrial managers emphasized this and indicated that, by employing university researchers in parts of their internal R&D organization, the industrial partner is able to fully utilize the results of the joint research.

> After finalizing their doctoral degree, we have employed most of the researchers working on our joint projects. They have then continued their development work as part of our R&D organization. (IND F)

> It is quite typical that a person who has first worked as a researcher has then continued his or her work as a part of our internal R&D staff. (IND B)

> During the years of collaboration, several members of our research staff have been employed by the company. (UNIV C)

Thus, the importance of the boundary spanning activities in the relationship between scientists and industry (Siegel *et al.*, 2004) is again emphasized, but this time in the context of the implementation of jointly created knowledge.

For universities, publishing the research results is an essential outcome of the research projects, and in many cases the academics need to engage in "status competitions" with their peers and colleagues, based on their publication records and other institutional affiliations (Geuna and Nesta, 2006; Bruneel *et al.*, 2010), which are critical for their success and career sustainability in the academic world. On the other hand, the companies may often wish to keep research results secret to ensure a potential competitive advantage facilitated by this new knowledge. Again, working with universities requires that the firms have the ability to collaborate with partners with a different incentive system (Siegel *et al.*, 2004; Bruneel *et al.*, 2010). In the same way, universities have to understand the importance of intellectual property (IP) for industry. For example, establishing expectations concerning what aspects of and when the results of the joint projects can be published by the university researchers may be controversial (Bruneel *et al.*, 2010). Our interview data concerning knowledge integration revealed that academics and industrial actors are able to find a consensus regarding the publication policy:

> We try to focus our joint research in such a way that at least part of the results can be published by the university researchers. In many cases, we have patented the new idea first and allowed the researcher publish it after that. (IND F)

> Usually, we have found a way to publish the results as soon as the IP issues have been agreed with the company partner. However, this has sometimes not been possible, which is of course very demotivating for the researcher, but we have to accept this with industrial projects. (UNIV F)

> We always negotiate with our partner about what can be published and usually we have together found areas of research that can be published. (UNIV B)

The interview data revealed an interesting opportunity in terms of overcoming the potential conflicts concerning the publication of the jointly developed research results by authoring the publications together:

> We know that it is important to our university partner to publish the results, but it is not always possible. On many joint projects, we have decided together what can be published and how, and then we have written the papers together. (IND B)

> I feel that the joint authoring of scientific papers also really helps the industry people to deeply understand the methods and technologies that we are developing together from a scientific perspective. They also seem to appreciate the opportunity to co-author the publications. (UNIV D)

> Working together on a research paper helps the company's R&D staff to understand academic research and our way of working. It also makes our collaboration closer, since the writing process is often a quite demanding part of the project. (UNIV B)

Thus, joint scientific publications (D'Este and Patel, 2007) can be an important way of deepening the relationship between university and industry actors, as well as facilitating joint knowledge creation in the relationship and bringing the partners closer to each other.

5. Discussion and conclusions

The present study extends the existing literature on UIR learning by presenting a qualitative case study on organizational learning practices in UIRs. This is an important research setting, given that UIR relationships tend to vary in terms of their learning capabilities, with some relationships performing better and producing more highly innovative outcomes than others, because they have been able to develop appropriate learning mechanisms. By identifying relationship learning practices, this study makes three important contributions. First, the study extends the existing, mainly qualitative, literature on interorganizational learning (Selnes and Sallis, 2003; Fang *et al.*, 2011) by providing qualitative evidence on the practices on how partners in long-term UIRs deepen and develop their learning. Second, the results of the study highlight a number of mechanisms and practices that help UIR actors to cope with competing demands between learning and protection (Kale *et al.*, 2000), a topic that is widely neglected in the existing UIR literature (Siegel *et al.*, 2004; Bruneel *et al.*, 2010; Perkmann *et al.*, 2013). Third, the study contributes to the research on UIR collaborations by demonstrating how the identified learning practices also help actors to lower the barriers to effective relationship learning. These barriers, which are caused by different institutional norms concerning the openness towards knowledge, as well as different motivations, attitudes and organizational cultures, have been recognized as a major obstacle for effective learning in UIRs (Bruneel *et al.*, 2010). This study is one of the few providing qualitative evidence on real-life practices to lower these barriers.

The study has examined learning practices in three phases of relationship learning (Selnes and Sallis, 2003), as summarized in Figure 1. Knowledge transfer is the first phase in this process. One of the main barriers to efficient knowledge transfer in UIRs is the level of openness concerning commercially sensitive industrial knowledge, with our data having emphasized the role of mutual trust between partners, which can stimulate rich information exchange and the sharing of valuable knowledge. High levels of trust in the relationship enable the industrial partner to disclose sensitive information, which may be commercially advantageous, but is necessary for research partners to carry out the relevant research. The observations revealed that long-term and close personal-level interactions between key stakeholders in the relationships are the most important factors facilitating the creation of mutual trust, which also facilitates commitment between partners. Commitment, in turn, positively impacts on the partners' adaptation to each other's processes and way of working.

In the joint knowledge creation through the process of sense-making the main organizational barriers are related to different motives, attitudes and organizational cultures between partners. As the actors involved have totally different incentive systems, they have to find ways to make their collaboration motivating on both sides. The data suggested that industrial partners can carry out concrete actions to motivate collaboration by extending their own incentive systems to cover university staff working on joint projects. In the similar manner, universities may provide incentives for the researchers for participating the industrial projects. The role of boundary actors' engagement in university collaborations was found to be particularly important for the relationship learning process, and therefore the industrial collaborators must be active in encouraging their staff for crossing the

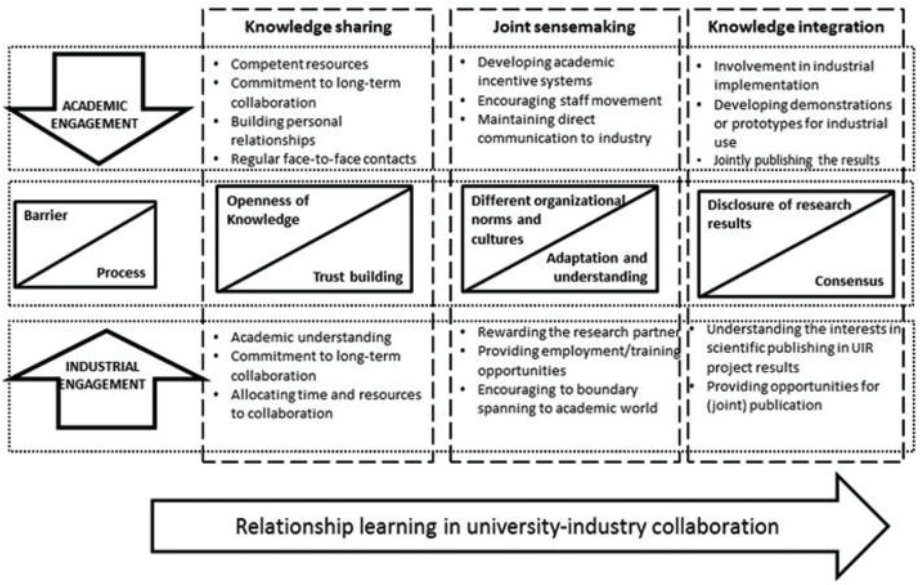

Figure 1.
A summary of central practices, which facilitate the lowering of barriers in the relationship learning process within university-industry collaboration

boundary between industry and academia. In the same manner, to facilitate and motivate academic involvement in industrial collaboration, academics have to be business-oriented and understand the industrial way of working if they are to adapt to their partners' processes. In this way, the experience of collaboration may enable academics and their industrial collaborators to converge in terms of attitudes and arrive at a mutual understanding about the research process and collaboration practices.

The third phase, integration of knowledge with relationship-specific shared memory, refers to the implementation of the knowledge accumulated in the relationship. Conflicting interests related to the openness of research results may often yield to conflicts between partners over attitudes towards the timing and format of the publication of the research results. This is because companies wish to keep the results secret from their competitors, while academics, on the other hand, wish to facilitate open knowledge, such that their ideas may be acknowledged by their peers. However, the data revealed that partners are able to find a consensus in this regard through negotiation and by understanding the interests of the other party. In addition, publishing the results together with the industrial partner provides academics with an interesting way of creating publications with real-world applications, as well as deepens the relationship with the industrial partner.

In conclusion, establishing a successful learning relationship between industry and academia requires the long-term investment, understanding and adaptation on the part of both parties at several organizational levels. This study presents several relational practices that facilitate knowledge sharing, creation and integration by aligning attitudes and ways of working on both sides of the relationship. The study also highlights the meaning of interorganizational trust facilitated by overlapping personal and professional relationships and close interactions – processes necessary to create the right atmosphere, in which partners can jointly create and utilize knowledge and overcome barriers caused by different orientations, attitudes and incentives.

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Technology Innovation Management Review December 2017 (Volume 7, Issue 12)

Educational Involvement in Innovative University–Industry Collaboration

Leena Kunttu

> *"Even if the relationship between us and our university partner has been primarily a research collaboration serving our R&D, the educational dimension of this collaboration has also been very important in developing us new skills and competences in new fields. Thus, by involving with educational activities, we have enabled efficient knowledge transfer from the academic world to our own R&D."*
>
> Technology Manager
> Case company D

The positive link between university research and industrial innovation has been widely recognized among academics and industrial practitioners. A remarkable volume of previous research emphasizes the importance of the transfer of academic knowledge into the industrial domain. In this sense, it is surprising that the role of university education is an almost neglected topic in the research concerning university–industry collaboration, despite education and the creation of knowledge being a primary goal of universities and providing great potential in terms of improving competences. This study presents a case study that analyzes educational involvement in nine long-term university–industry relationships. In all the cases, the research collaboration between industrial firm and university research group is directly associated with close educational involvement. The aim of the case analysis is to understand mechanisms and practices of educational collaboration that facilitate relational learning and innovation development in university–industry relationships. The forms of educational involvement studied in this article include student projects, thesis projects, jointly organized courses, and tailored degree courses. The findings of the study reveal a number of educational collaboration practices that may facilitate relational learning, creation of new knowledge, as well as innovation development in university–industry relationships.

Introduction

Previous research has shown that innovative research collaboration between universities and industrial firms may effectively facilitate shared knowledge creation, learning, and joint innovation and, therefore, it acts as a stimulator of economic growth (Laursen & Salter, 2004; Weckowska, 2015). University–industry relationships typically involve collaborative research, contract research, educational collaboration, personnel mobility, or contracting (D'Este & Patel, 2007; Perkmann et al., 2013). Whereas the importance of the transfer of academic knowledge into the industrial domain has been highlighted in previous research (e.g., Ankrah & Al-Tabbaa, 2015; Perkmann et al., 2013), educational collaboration taking place as a part of university–industry research collaborations is an almost neglected topic. This is surprising, because education and the creation of knowledge is a primary goal of universities, and involvement in academic educational activities is a source of great potential in terms of improving the competences of firms seeking new skills and competences (Santoro & Chakrabarti, 1999) or wishing to develop their own internal capabilities. Indeed, previous studies on university–industry relationships mention education, training, and student projects as potential academic opportunities for industrial actors participating in university–industry relationships, for facilitators of a deepening academic engagement between the parties (Arvanitis et al., 2008; Bruneel et al., 2010; Perkmann et

Technology Innovation Management Review December 2017 (Volume 7, Issue 12)

Educational Involvement in Innovative University–Industry Collaboration

Leena Kunttu

al., 2013), and for contributors to the creation of joint knowledge (Weckowska, 2015). However, prior understanding of *how* educational activities contribute the creation of joint knowledge and learning in university–industry relationships is very limited.

Educational collaboration can be defined as interactions between academic institutions and non-academic organizations involving academic educational activities. Thus, educational collaboration in university–industry relationships may consist of joint educational activities, training, or different kinds of student projects (Arvanitis et al., 2008; Bruneel et al., 2010; Maietta, 2015; Perkmann et al., 2013), all taking place in the relationships between academia and industry. To understand the facilitating practices of educational collaboration in university–industry relationships, this article uses the theory of relational joint learning (Kuwada, 1998; Selnes & Sallis, 2003) as a theoretical framework. The relational learning approach has so far received relatively little research interest in the context of university–industry relationships (Weckowska, 2015), despite scholars showing that the learning process that takes place in collaborative relationships is an essential enabler of joint innovation involving knowledge creation, transfer, interpretation, and utilization (Bäck & Kohtamäki, 2016; Selnes & Sallis, 2003). Moreover, the innovativeness of firms participating in university–industry relationships has been shown to be dependent on how successful they are at acquiring and developing knowledge through learning in these collaborative relationships (Bruneel et al., 2010; Laursen & Salter, 2004). This study intends to answer the following research question: *How can educational collaboration facilitate relational learning and knowledge creation in university–industry relationships?* To address this question, this article presents nine case examples of successful educational involvement in long-term university–industry research collaboration.

Relational Learning in University–Industry Relationships

The learning process taking place in relationships between industry and universities has been recognized as an essential facilitator of the transfer and integration of new, external knowledge in firms. This relational learning process also helps partners to jointly build new internal capabilities for innovation and to identify ways of joint knowledge development and utilization towards commercial ends (Weckowska, 2015). In this study, the relational learning approach is applied to the collaboration taking place in university–industry relationships. Selnes and Sallis (2003) define relational learning as a joint activity between two parties, in which they share information, which is then jointly interpreted and integrated into a shared relationship domain-specific memory. Thus, the relational learning process consist of three interconnected phases in which the research partners "1) share knowledge, 2) jointly make sense of it, and 3) integrate that knowledge into relational memory" (Selnes & Sallis, 2003). In the first phase, *knowledge sharing,* the partners share and transfer information and knowledge in formal and informal manners within their relationship. In the context of university–industry relationships, the process of knowledge transfer from academia to industry has been studied by several teams of researchers (e.g., Ankrah et al., 2013; D'Este & Patel, 2007; Siegel et al., 2004). Typical forms of knowledge transfer include jointly organized research projects, training and education, consulting engagements, or thesis supervision. The transfer of technological knowledge is an important part of the relational learning process, because innovative collaboration involves close sharing of experience-based specialized knowledge that is often tacit in nature. In the second phase, *joint sensemaking,* the partners work together to achieve a mutual understanding, create new knowledge, and solve practical problems in their common development work (Selnes & Sallis, 2003). Thus, the joint sensemaking combines the resources, competences. and previous knowledge of the partners to jointly develop new knowledge that is typically relationship specific and thus difficult to utilize outside the partnership. The third phase, *knowledge integration,* refers to the integration of the jointly developed knowledge, capabilities, and skills into a part of the relational memory owned by the partners. In university–industry collaboration, the partners often integrate the outcomes of their joint development processes as commercialized innovations, prototypes, or academic outcomes (Perkmann et al., 2013).

Case Study on Educational Involvement in University–Industry Relationships

To explore the involvement of industrial firm in university education as a part of their innovation collaboration with universities, this study presents a comparative, qualitative multiple case study of nine long-term university–industry relationships in Finland (Table 1). The cases were selected purposively following the concept of information-rich cases (Patton, 1990). Thus, all nine cases represented a close and long-term collaboration between a university research group (typically led by a professor or assistant professor) and an industrial firm's R&D function. All the cases also included educational collaboration that has directly contributed to the rela-

Technology Innovation Management Review December 2017 (Volume 7, Issue 12)

Educational Involvement in Innovative University–Industry Collaboration

Leena Kunttu

Table 1. Case study descriptions for the studied relationships between universities and industrial partners

	Industrial Area	Relationship Age	Joint R&D Project Area	Forms of Educational Collaboration	Industry Participants	University Participants
Case A	Electronic and electrical systems	4 years	Process development for R&D function	Student projects	R&D Director	Leader of the research group
Case B	Mobile devices	5 years	Software and algorithm development	Student projects, Thesis projects, Jointly organized courses	Research Manager	Leader of the research group
Case C	Software products	4 years	Software and algorithm development	Student projects, Thesis projects	Project Manager	Leader of the research group
Case D	Software for mobile devices	5 years	Algorithm development	Tailored degree courses, Thesis projects, Jointly organized courses	Technology Manager	Leader of the research group
Case E	Hardware platforms and embedded software	5 years	Software development	Student projects, Thesis projects	R&D Manager	Leader of the research group
Case F	Power electronics products	13 years	Hardware and related embedded software development	Tailored degree courses, Thesis projects	Senior Director, Global Innovation	Leader of the research group
Case G	Telecoms	3 years	Service product development	Student projects, Thesis projects	Development Director	Leader of the research group
Case H	Engines and power plants	5 years	Service product development	Student projects, Thesis projects	Business Development Director	Leader of the research group
Case I	Heating systems	6 years	Service product development	Student projects	R&D Director	Leader of the research group

Technology Innovation Management Review December 2017 (Volume 7, Issue 12)

Educational Involvement in Innovative University–Industry Collaboration

Leena Kunttu

tional learning outcomes and innovation capabilities developed in the relationships. In most of the university–industry relationships studied, the collaboration had started as a research collaboration and the educational aspects evolved gradually over the years of collaboration. The data was collected on each case by means of recorded and transcribed interviews and the analysis of secondary materials, such as websites, company reports, and teaching materials. Each of the case interviews involved an interviewee on both sides of each case relationship, and all the interviewees were the key contributors to the relationship who also had directly participated in the educational aspects throughout the collaboration. To maintain confidentiality of the interview data, the interviewees are identified only by position (university=UNIV; industry=IND). The structure of the interviews were divided into three parts following the three phases of relational learning: 1) knowledge sharing, 2) joint sensemaking, and 3) knowledge integration. The interview data revealed that the educational collaboration in the selected university–industry relationships included the following four forms of educational collaboration:

1. *Student projects for groups of undergraduate students.* The projects were usually organized by universities as a part of their curriculum. The topics of the projects were initiated by the research project on university–industry relationships, and they were jointly supervised by industrial and university staff.

2. *Thesis projects.* Thesis projects were typically related to Master's or PhD theses. In this case, relevant thesis topics were also usually initiated by the research project, and they were co-supervised by university professors and industrial managers.

3. *Tailored degree courses.* The courses were organized by the university in cases where the industrial partner needed certain types of unique skills; that partner would then often provide employment opportunities for students who had passed these courses. The industrial partner's own R&D staff also frequently taught and studied on these courses.

4. *Jointly organized courses.* These courses were organized jointly by the university and the industrial partner around the central topics related to the project on university–industry relationships. The teaching was organized jointly by university researchers and industrial R&D staff. The audience for the course was typically undergraduate or postgraduate students from the university, as well as industrial R&D staff.

Results

This section presents an analysis of the interview data collected from each case in terms of knowledge sharing, joint sensemaking, and knowledge integration. At the end of this section, Table 2 summarizes the key findings.

Knowledge sharing

Transferring knowledge is one the primary drivers of innovation in inter-organizational collaboration (Tsai, 2001) in which both partners have to share their own previous knowledge and information that can often be tacit or experimental in nature. However, information sharing between partners requires an open and trusted atmosphere, particularly given that the information owned by the industrial actor in the relationship has both economic value and potential competitive advantage (Santoro & Saparito, 2003). Therefore, the knowledge sharing and transfer in university–industry relationships requires engagement and commitment to the collaboration from both parties (Ankrah et al., 2013). The interview data showed that efficient knowledge transfer in the educational collaboration was based on long-term and close collaboration and person-level relationships between industrial actors and universities:

> *"Our research collaboration started some years ago, and it has been gradually extended as good results have been achieved, and people from both sides have become more familiar to each other. We started to participate to the educational activities quite recently, since we felt that it could support our research collaboration."* (IND G)

> *"I feel that long-term personal relationships between the industrial partner's R&D staff and our researchers represent one of the most critical facilitators of close collaboration and open communication in this relationship."* (UNIV D)

The interview data also revealed that perhaps the most important form of educational knowledge transfer in the cases studied is different kinds of thesis projects:

> *"In our joint research projects, thesis projects were carried out from the beginning, but other forms of educational collaboration started after the collaboration had been ongoing for quite some time."* (IND B)

Technology Innovation Management Review December 2017 (Volume 7, Issue 12)

Educational Involvement in Innovative University–Industry Collaboration

Leena Kunttu

> *"I try to find competent students to who will base their theses (at both Master's and PhD levels) within the industrial projects around practical themes that really benefit our industrial partner. This way, the students become integrated into the industrial way of working, and many of them have also continued to work as employees of the industrial partner after graduation."* (UNIV F)

The interview data also revealed that thesis projects can only be successful when the student writing the thesis is able to obtain relevant and good-quality supervision from both sides of the relationship. Here, again, the role of a trustful and close collaboration between universities and industry is emphasized (Santoro & Saparito, 2003):

> *"Joint supervision also involves a great deal of direct interaction between us and the industrial partner, which can also generate new ideas and valuable knowledge transfer outside of the thesis project."* (UNIV D)

> *"Many times, a thesis project has paved the way to a wider joint research project between us and our industrial partner."* (IND E)

> *"Based on my experience, even a competent Master's student with a relevant background needs supervision from both university professors and the industrial partner to reach a successful outcome in their thesis project."* (IND F)

The interview data in cases B and D also emphasizes the meaning of jointly organized courses in knowledge transfer between parties. The idea behind this kind of joint education is to involve both university staff and industrial R&D specialists both as lecturers and participants in the course, and in this manner provide both parties education on a new and important topic. Based on the interviews, these kinds of courses seem to be an effective way of gaining knowledge and skills in a new research area on both sides of the relationship:

> *"We have jointly organized courses with academia on central topics of our R&D. The idea is to invite lecturers from both our organization and from our university partner to give lectures on the topic, which we then discuss together. The audience of the courses includes our R&D staff and university researchers and students. Personally, I feel that this kind of joint working is a really effective way of gaining knowledge on the area in question, and it definitely benefits both parties."* (IND B)

> *"Feedback from students and researchers regarding these courses has been outstanding."* (UNIV B)

> *"The joint courses provide us as researchers, and also our students, with an excellent opportunity to apply our knowledge in a practical industrial context, to learn practical viewpoints and also to initiate new research directions together with industry."* (UNIV D)

The interview data in cases B and D also shows that the joint educational activities have improved the knowledge transfer, interaction, and communication between the partners also outside the course activities. This is because the courses usually involve new people in the collaboration from both sides and help them to connect. This, in turn, often facilitates the development of new ideas and initiatives for further research directions:

> *"Several kinds of excellent ideas have been born during the discussions at these courses."* (IND D)

Joint sensemaking

The development of new knowledge, ideas, and innovations in the collaborative relationship takes place in the process of joint sensemaking (Selnes & Sallis 2003). In this process, the academic and industrial partners jointly work on development tasks in order to solve technical problems and other tasks related to their mutual development projects (Bäck & Kohtamäki, 2016). In this effort, the partners can bring their own skills, knowledge, and earlier experience to the collaborative process and jointly create new, experimental knowledge. In the context of educational involvement, different kinds of student projects represent a central form of joint sensemaking between universities and industry. The purpose of the student projects is to involve university students in building a project around subjects provided by industry so that they can utilize their studies and apply the studied content in practice. The interview data confirms that this kind of practical learning procedure can facilitate learning within the relationship and the joint development of innovations (Brown & Duguid, 1991):

> *"I have been teaching and supervising the student groups undertaking these practical projects for several years. In my opinion, students are very motivated to work on these projects. The students are particularly eager to collect information and use their knowledge to solve problems provided by the industrial partner, especially when it also involves this work."* (UNIV A)

Technology Innovation Management Review December 2017 (Volume 7, Issue 12)

Educational Involvement in Innovative University–Industry Collaboration

Leena Kunttu

> *"The results of the development work in the student work were so beneficial to our own development work that we decided to continue this kind of collaboration with our university partner from year to year."* (IND I)

Thus, the interview data emphasized the importance of student projects as a valuable research resource in the joint research projects. The industrial actors especially appreciated the student groups' ability and eagerness to provide the firms with new views, ideas, and insights on the novel areas that were not so familiar to the firms' internal development staff:

> *"For us, student projects provide new and fresh insights, views, and ideas to support our own development work. They also increase our knowledge in the areas dealt with by the project work topics."* (IND H)

Another area that arose in the interviews was the student groups' ability to collect and analyze valuable field data on, for example, customer experience, trends, and behaviour:

> *"It was a surprise to us how much valuable customer information and how many development ideas the student groups can collect in these projects. During their joint discussions with us, we can develop these ideas together in a way that really contributes to our internal R&D."* (IND E)

> *"The student groups have provided us with a lot of very useful information that would have been difficult to collect by ourselves."* (IND H)

However, the majority of the interviewees also recognized that the student project work can only be successful when is properly guided and supervised by both industrial and academic parties:

> *"The university student groups are really a good and valuable resource, especially if both we and the university research staff have enough time to supervise them in the right direction."* (IND B)

> *"We have achieved good results from student projects, especially with tasks where the projects are designed around a practical problem that somehow fits into the competence profiles and background of the students. Naturally, we have to put in extra effort to guide this work, but in any case it is a great learning experience for all of us."* (UNIV A)

Another educational aspect of the collaboration includes dedicated degree courses for university students. The motivation behind these courses is usually a practical need for certain specific and unique skills that the industrial partner is lacking. The partner university then organizes this kind of education for its students, who were typically near to graduation:

> *"We have tried to answer to our industrial partner's educational needs by providing our students with courses containing dedicated content. It was also quite common for the industrial partner's internal R&D staff to attend these courses, either as audience members or as lecturers or supervisors."* (UNIV F)

> *"Opportunities to participate and give input to the degree courses provided by the university have been important to our R&D. This way, we have been able to recruit graduates with a certain important competences."* (IND D)

In some cases, the industrial partner has also provided teaching materials or tools to support university education in the selected field:

> *"We have provided our internal software development and testing environment targeted for experimenting with different kinds of new ideas for the use of universities, so that students can test their own ideas as part of their courses in this field."* (IND B)

> *"The materials provided by the industrial partner, as well as the experiences from our joint projects, are very valuable practical teaching materials."* (UNIV D)

This collaboration on dedicated degree courses is also important in terms of knowledge transfer, because many of the students who passed these courses ended up becoming employees of the companies:

> *"During these years of university collaboration, we have employed a number of students in this field after their graduation."* (IND F)

> *"A significant number of our previous students, on both Master's and Doctoral levels, now work as members of the industrial partner's R&D staff."* (UNIV F)

Technology Innovation Management Review December 2017 (Volume 7, Issue 12)

Educational Involvement in Innovative University–Industry Collaboration

Leena Kunttu

Knowledge integration

The third part of the relational learning process (Selnes & Sallis, 2003) is related to the knowledge integration and implementation. The knowledge integration in university–industry relationships may involve the industrial commercialization of jointly developed innovations or technological solutions, such as commercialized product, process or service innovations, prototypes or other practical outcomes of the joint development work (Perkmann et al., 2013). In the case interviews, the interviewees were asked about the practical outcomes of the educational collaboration:

> *"The students should be able to present and document their project outcomes in a way that our internal developers can utilize them."* (IND E)

> *"I know that many university professors appreciate academic outcomes such as publications more than practical ones, but I feel that the industrial collaboration project is only successful when the results can really be utilized in industry."* (UNIV A)

Thesis projects and student group projects are typical examples of educational outcomes that have practical value for industry. However, the interview data shows that the results can be utilized only when they are presented in a practical manner:

> *"From our point of view, the outcomes of the student projects should not be scientific reports, but instead well-documented and implemented demonstrations of the developed methods that are both easy to understand and to further develop within our organization."* (IND A)

> *"A well-made Master's thesis project has been the starting point for many successful internal R&D projects."* (IND F)

> *"Even if a Master's or doctoral thesis is the primary result of academic work, we encourage students contributing to the industrial projects to write their documentation in such a way that it also meets the industrial partner's needs."* (UNIV F)

One effective way to integrate the results of educational involvement is to also employ the students in the industrial implementation process. Thus, in all of the university–industry relationships studied in this article, the industrial partners have employed the students who contributed to their projects after their graduation:

> *"Many project or thesis workers have continued to work on their topic as part of our R&D organization."* (IND B)

> *"Several of our previous students who contributed to the industrial partner's research projects in some way have been employed by the company."* (UNIV C)

> *"Experience has shown that one of the most effective ways of integrating research-based knowledge to our industrial goals is to recruit the person who has studied the topic within a university research group."* (IND D)

Thus, boundary spanning activities in the relationship between scientists and industry (Siegel et al., 2004) represent an important way of integrating the knowledge obtained in educational collaboration within university–industry relationships.

Conclusion

This study presented a qualitative analysis of nine cases of educational involvement in university–industry research collaboration. The main goal of the study was to analyze the mechanisms and practices that are related to the educational aspects of this collaboration. The empirical analysis presented in the article indicates that this collaboration provides a number of factors that may facilitate relational learning, collaborative practices, and the creation of new knowledge in university–industry relationships, as summarized in Table 2. First, when industrial firms are given the opportunity to employ university students in their research projects in parallel with university research staff, many kinds of practical benefits can be achieved. For instance, almost all of the industrial managers interviewed mentioned university student projects as a valuable channel for new ideas, insights to customer experience and behaviour, as well as being an efficient way of recruiting competent R&D staff to companies. Particularly, the recruitment of graduates with specific competences obtained in the university research projects has proved to be a very efficient way of transferring academic knowledge to industry. Second, jointly organized educational activities, such as training courses targeted to both university students and company internals, are an efficient method of gaining internal skills for the company and absorbing new information from the academic world. In a similar manner, these activities provide universities with access to real-world industrial R&D work and

Technology Innovation Management Review December 2017 (Volume 7, Issue 12)

Educational Involvement in Innovative University–Industry Collaboration

Leena Kunttu

Table 2. A summary of the main findings of this study on university–industry relationships

	Knowledge Sharing	Joint Sensemaking	Knowledge Integration
Student Projects	• An effective method for transferring practical knowledge from research or the field	• Establish interaction between the students and industrial partner • Joint efforts to solve practical industrial problems • Provide new insights and fresh ideas "from the outside world"	• Provide practical results • Involvement in industrial implementation
Thesis Projects	• An important way of transferring practical academic knowledge • Joint supervision of theses facilitates university–industry collaboration and interaction	• Open new development areas • Deepen university–industry collaboration • Provide industrial partner with easy opportunities to collaboration with research groups	• Clear documentation facilitates industrial utilization • Employing the graduate is an easy way of integrating the knowledge into industry
Tailored Degree Courses	• Are able to facilitate gaining new academic competences and resources that can be accessed by industry	• Joint working and discussions in the courses facilitate joint knowledge creation and deepen research-based collaboration	• Integrating the new competences through recruitments
Jointly Organized Courses	• Represent an effective way of gaining knowledge and competences in a new research area (on both sides of the collaboration)	• Joint working and discussions in the courses facilitate joint knowledge creation and deepen research-based collaboration	• Implementing the most promising ideas developed in the coursework

the challenges that come with it. Third, the interview data revealed that all educational activities involving industrial partners facilitate research-based information transfer from academia to industry, and they help industrial partners to efficiently utilize this information. This transfer is particularly important when the industrial partner needs to improve its skills in new, knowledge-intensive areas. Fourth, educational collaboration deepens research-based collaboration between academia and industry, which helps both sides to develop similar attitudes and arrive at a mutual understanding regarding the research process and collaborative practices.

The findings of the study are also of managerial interest given that most high-technology companies utilize collaborative university partnerships for their innovation and product development work, and thus face the challenge of utilizing the results achieved in this collaboration. This study presents a variety of collaborative practices that include educational involvement and that have a positive impact on these research collaborations, especially in terms of relational learning, knowledge creation, and commitment to the collaboration.

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Technology Innovation Management Review December 2017 (Volume 7, Issue 12)

Educational Involvement in Innovative University–Industry Collaboration

Leena Kunttu

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Technology Innovation Management Review June 2018 (Volume 8, Issue 6)

How Doctoral Students and Graduates Can Facilitate Boundary Spanning between Academia and Industry

Leena Kunttu, Essi Huttu, and Yrjö Neuvo

> *"This doctoral education program is an excellent example of practical collaboration with universities. We can develop our own internal competences with the newest scientific knowledge. Moreover, we can familiarize our potential future workforce with practical industrial R&D work and with its challenges and innovation opportunities. This kind of jointly organized doctoral program is, for us, a natural channel for recruiting highly skilled experts from the academic world."*
>
> Industrial partner interviewed in this study

The mobility of scientific competences from universities to industrial firms enables firms to absorb and utilize the knowledge developed in academia. However, too few young doctors are currently employed in industry, despite the fact that they could transfer and integrate valuable academic knowledge for industrial purposes and facilitate its utilization towards commercial ends. In this article, we investigate the role of doctoral students and graduates as academic boundary spanners by presenting three joint programs between universities and industrial players that facilitate and promote the industrial involvement of doctoral students and graduates. The cases highlight the meaning of university–industry collaboration in doctoral education and present practical examples of how industrial firms may facilitate the transfer of academic knowledge to industry through jointly organized doctoral education and postdoctoral mobility programs.

Introduction

The results of academic research developed towards commercial ends provide industrial firms with a way to improve their competitiveness, and thus effective knowledge transfer between academia and industry can be a powerful source of innovation (Laursen & Salter, 2004; Perkmann et al., 2013; Siegel et al., 2004). The ability of an industry sector to utilize the knowledge of a highly educated workforce is an important factor in improving its innovative capacity and the economy overall (Weckowska, 2015). However, maintaining competitiveness and further strengthening it requires constant monitoring and analysis of new technological and operational trends. Intensifying international competition and accelerating speed of change require that industrial firms not only have the ability to implement the latest innovations, but also actively create new innovations (Gassmann et al., 2010).

One of the most essential ways of transferring knowledge is to facilitate the mobility of academics to industry and vice versa. Recruiting newly graduated doctors has been found to be an effective method of transferring and integrating the latest academic knowledge for industrial purposes (Kunttu, 2017). Doctors have the most up-to-date scholarly knowledge in their field, and they are capable of attacking demanding problems with scientific rigour. However, relatively few doctors are actually employed in industrial firms in Western Europe (Auriol et al., 2013), despite the fact that the countries in this region have graduated a rapidly increasing number of doctors in recent decades. For instance, in high-technology countries such as Finland and Sweden, only about 25–30% graduated doctors are employed in private sector.

When people move between academia and industry, they have to cross different organizational boundaries

Technology Innovation Management Review June 2018 (Volume 8, Issue 6)

How Doctoral Students and Graduates Can Facilitate Boundary Spanning between Academia and Industry

Leena Kunttu, Essi Huttu, and Yrjö Neuvo

(Rajalo & Vadi, 2017), because the institutions operate under different environments and cultures caused by their own norms, motives, and values (Bruneel et al., 2010). For this reason, university–industry boundaries often represent obstacles to establishing close interactions between actors on either side. Reflecting this challenge, doctoral students working in universities often focus on relatively narrow topics defined by academic priorities, but without a clear connection to real-world industrial work (Kunttu, 2017). Therefore, facilitating practices for boundary spanning and relevant social processes are necessary to open new avenues for interaction and integration of doctoral students with an industrial environment.

Thus, boundary spanning is an important skill or behaviour for actors who actively aim at transferring academic knowledge between academia and industry (Ankrah & Al-Tabbaa, 2015). These boundary actors may serve as a bridge between industrial firms ("customers") and academic institutions ("suppliers"), who operate in different environments with different motives, cultures, and actions (Siegel et al., 2004). The doctoral candidates and young doctors who engage in industrial domains represent boundary actors who may operate across the boundary between university and industry and thus help to transfer knowledge in both directions.

Previous research has highlighted the importance of the academic engagement and knowledge transfer in university–industry collaboration (Ankrah & Al-Tabbaa, 2015; Ankrah et al., 2013; Perkmann et al., 2013), but this research falls short in its analysis of educational collaboration and in the role of students and graduates as boundary spanners. As indicated by Ankrah and Al-Tabbaa (2015) in their recent systematic literature review on university–industry collaboration: "...the impact of academic engagement in the process of UIC [university–industry collaboration] is almost overlooked. For example, none of the reviewed studies have addressed the consequences of this engagement on, for example, teaching and learning experience of students affiliated with universities that engaged with the industry. This line of research can provide supporting evidence to the intangible potential value of the UIC (Perkmann et al., 2013)."

To address this gap, this study intends to answer the following research questions:

- *How can jointly organized doctoral education programs facilitate the mobility of doctoral students and graduates from academia to industry?*
- *What kinds of boundary spanning practices are related to these programs?*

To address these questions, we present a case study investigating three doctoral education programs that focus on the mobility of doctoral graduates from academia to industry. All these programs aim at familiarizing the students with an industrial way of working and by providing them with real industrial problems to which they can apply their academic knowledge and problem-solving skills. By using these kinds of educational programs, the universities and industry are able together lowering the boundaries between these two types of institutions and facilitate effective knowledge transfer between them.

The remainder of the article is organized as follows. The following section describes three cases of doctoral education programs designed to facilitate boundary spanning between academia and industry. After that, we present and discuss our findings. Next, we highlight the practical implications of the findings. Finally, we offer conclusions.

Three Cases of Boundary Spanning

This study presents three cases of boundary spanning in the context of university–industry collaboration, as summarized in Table 1. The authors of this article are the main organizers of the courses described in the three cases (Case 1: Neuvo; Case 2: Kunttu; Case 3: Huttu) and are the main source of information about these cases. Additional data used in the case descriptions included interviews and feedback from the course participants as well as materials produced during the courses.

Case 1: Bit Bang

The first case presents the Bit Bang doctoral training course, which has been run annually throughout the full academic year at Aalto University, Finland, since 2008. This postgraduate course is built around a general theme specified every year. The course relies on multidisciplinary and multinational teamwork assignments in the area of the course theme, and top-class guest lectures from industry leaders. The course adapts Nokia's top management training program to the academic environment. The course aims at facilitating collaboration across disciplines and, what is even more important, provides a bridge between academic post-graduate studies and industrial real-world challenges. The students work on specific assignments in student teams under the supervision of experienced tutors, and they

Technology Innovation Management Review June 2018 (Volume 8, Issue 6)

How Doctoral Students and Graduates Can Facilitate Boundary Spanning between Academia and Industry *Leena Kunttu, Essi Huttu, and Yrjö Neuvo*

Table 1. A summary of three cases of boundary spanning in university–industry collaboration

	Case 1	Case 2	Case 3
Activity name	Bit Bang	Nokia Mobile Imaging	PoDoCo Program
University partners	Aalto University	Tampere University of Technology, Aalto University	Several universities in Finland
Industrial partners	Nokia and other Finnish technology companies	Nokia	An industrial consortium
Target group	Doctoral students	Doctoral students	Doctoral graduates
Activities	Teamwork on course topics; guest lectures from industry; a week-long study tour	Teamwork on course topics; guest lectures from academia and industry	Research grant for a broad research phase followed by a targeted research phase funded by the industrial partner
Deliverables	An academic report authored by each student team	Presentations and reports	Company-specific research results
Impact on students	The majority of student participants were hired by industrial firms after doctoral graduation.		
Impact on companies	The companies benefitted from new scientific knowledge and relationship building with potential new employees.		

jointly author a report on their team-specific topic. The highlight of the course is a week-long intensive study tour to a globally recognized region of research, innovation, and business. Past locations for the study tour have included Shangai, Tokyo, Bangalore, New York, and California, and each tour includes both company and academic site visits. The course has been organized nine times, and the total number of participants has been about 200. The majority of the students have been hired by industrial firms after following their graduation, and many also still participate in the program as tutors or guest lecturers or are still actively involved by attending Bit Bang events. Papers produced by students during their Bit Bang collaboration have produced interesting results: many participants have gone on to write conference papers and journal articles based on the joint reports written in class.

Case 2: Nokia Mobile Imaging

The second case presents a series of company-specific university collaboration courses organized between Nokia and Finnish universities during 2008–2010. The purpose of the courses was to deepen understanding of topics related to image analysis and processing in mobile devices. The courses were built on the existing and quite intensive research collaboration between Nokia imaging software development and a consortium of Finnish university research groups. The main idea in organizing the courses was to facilitate effective knowledge transfer between Nokia's imaging R&D team and the university research groups on selected topics in mobile imaging. In this manner, the academics were encouraged to present the most recent research-based knowledge in this area, whereas the company R&D staff brought their experience-based knowledge in the courses. The teaching was based on weekly meetings in which either a university professor or an R&D specialist from Nokia gave a lecture on a selected topic in their area of specialty. After the lecture, they all discussed the topic together. The team work was related to the course content and was based on a selected practical industrial problem, to which the teams were searching for a solution with the guidance of academic and industrial supervisors. The target audience for the courses was Nokia R&D staff and university doctoral students. There also were doctoral students who already worked in Nokia R&D, but who undertook doctoral studies after being encouraged by this kind of learning opportunity.

Technology Innovation Management Review June 2018 (Volume 8, Issue 6)

How Doctoral Students and Graduates Can Facilitate Boundary Spanning between Academia and Industry

Leena Kunttu, Essi Huttu, and Yrjö Neuvo

The doctoral students participating in the courses were given credits on the passed courses. The courses were organized in two consequent academic years around different themes. The theme for the first course was *Mobile Imaging* and for the second course theme was *Image Quality*. The total number of participants for both courses was about 60 people who were about equally divided between industrial R&D staff and academics.

Case 3: The PoDoCo program

The third case, the PoDoCo (PostDocs in Companies) program, is a joint initiative of Finnish universities, industry, and foundations. The aim of the program is to support the transition of doctoral graduates into private sector careers and, at the same time, enhance the strategic renewal of companies. PoDoCo facilitates novel meetings and matches newly graduated doctors with companies, and it financially supports the collaboration projects between doctors and companies. Annually, the PoDoCo program receives almost one million Euros annually in funding from its nine participating foundations and from companies participating in the program.

PoDoCo projects consist of two phases: broad research and targeted research. The aim of the first phase is to create far-reaching knowledge on a research topic of interest to both the doctor and the company. The PoDoCo foundation pool offers research grants of 6–12 months for this first phase. After the broad research phase has been completed, the company hires the doctor to deepen the research results and to create company-specific insights during the targeted research phase, which also lasts 6–12 months and is funded by the industrial partner.

The PoDoCo program has been running since 2015 and, so far, the program has received extremely positive responses from both companies and doctors. For companies, the PoDoCo program offers an opportunity to investigate new strategic openings with the help of talented doctors who are familiar with scientific analysis and synthesis methods and who possess the latest scientific knowledge. For doctors, the PoDoCo program offers an opportunity to work in the private sector, gain industrial experience, and establish important networks with companies. The result is a win-win situation where academic research is supporting the strategic renewal of companies and where doctors gain industrial experience. So far, 64 PoDoCo grants have been awarded, with the first PoDoCo collaboration projects starting in the spring of 2016 and ending during 2017. In the majority of these cases, following the completion of the research, the participating doctors have been hired by the companies they collaborated with, meaning that the PoDoCo program has successfully enabled a smooth transition from academia to the private sector. The PoDoCo program has also benefitted participating companies, many of whom have reported that the research conducted during the PoDoCo program has opened new avenues for growth.

Results and Discussion

The three doctoral education programs presented in this article show that collaborative programs in doctoral education train both industrial actors and academics through boundary-spanning activities.

A key finding of this study was that collaborative doctoral education programs jointly organized by academia and industry clearly facilitate and motivate the doctoral students and graduates to cross the border between academia and industry. A clear majority of the students participating in the programs continued their careers in industry after doctoral graduation.

We also found that the industrial players involved in the collaboration found it particularly beneficial that doctoral students were able to bring new and fresh ideas, innovative mindsets, and new scientific knowledge into the industrial domain. They also appreciated the opportunity to employ the newly graduated doctors into their internal R&D tasks, which facilitates the commercialization process of the university innovations developed in the doctoral projects. In this manner, the programs help the industrial firms to open doors for potential new employees with high scientific knowledge and skills, whose recruitment increases the firms' internal knowledge resources and capabilities.

The doctoral students underlined the importance of industrial experience and understanding of the industrial way of working that is possible to achieve by participating in the collaboration programs. Thus, such programs lower the threshold for doctoral graduates to transfer to an industrial career.

On the industry side, a related finding was that industrial R&D staff involving the collaboration were able to familiarize themselves with academic research and education. This, in turn, helps bring industry and academia closer to each other by establishing personal-level contacts and networks and by increasing mutual trust and relational capital, which are key factors to overcome organizational and cultural barriers between

academia and industry (Bruneel et al., 2010). In this way, the programs facilitate boundary spanning between these two types of institutions (Siegel et al., 2004).

Also, the Nokia Mobile Imaging case showed that jointly organized doctoral education programs may encourage technical staff working in industrial firms to start or continue doctoral studies. In addition to this, getting as many industrial employees as possible to participate the programs as students, mentors, supervisors, lecturers, or audience members can increase positive attitudes and mindsets towards university collaboration, which in turn makes them potential boundary actors (Siegel et al., 2004), and also promotes the research collaboration between universities and industry, as suggested by Kunttu (2017).

Practical Implications

In this article, we have presented three cases of doctoral education programs aiming at facilitating boundary spanning and mobility between industry and academia. However, these kinds of jointly organized educational programs represent rare examples in doctoral education in Finland and appear to be even rarer within an international context. For this reason, the collaborative practices for facilitating mobility presented in the cases can also be widely utilized in almost all kinds of doctoral education programs, and also in companies that do not have opportunities to participate in doctoral education programs. The key practices identified in this article include:

1. Involving industrial experts in the doctoral education program as guest lecturers, mentors, or supervisors.

2. Providing the doctoral student groups with project work topics that are directly connected to real-world industrial challenges.

3. Providing the doctoral students with opportunities for training or working on the relevant industrial topics during the doctoral studies.

4. Providing the doctoral students with research grants on a topic that is of industrial partner's interest.

5. Providing the doctoral students with the opportunity to continue the research work after graduation as company-internal employees.

Conclusion

This study sought to better understand how to address the problem that too few young doctors select industrial career after their graduation, despite the fact that these newly graduated doctors possess the latest scientific knowledge that could be applied towards commercial ends in the industrial domain. In this article, we showed that collaborative doctoral education jointly organized by academia and industry is not only able to encourage doctoral students to undertake industrial careers, but also to facilitate wider boundary-spanning activities between these institutions and, in this manner, lower organizational and cultural barriers between them.

All three doctoral education cases presented in this article reveal that industrial R&D may greatly benefit from participation in collaborative doctoral education by means of new scientific competences, fresh insights, and innovation mindsets provided by doctoral students and newly graduated doctors engaging in the industrial R&D. As boundary spanners, doctoral students and graduates can form a bridge between academia and industry. By engaging in the doctoral education and postdoctoral transfer programs, industrial firms are able to obtain valuable competences by engaging with doctoral students and graduates who not only transfer scientific knowledge to the firm but also take an active role in integrating and utilizing the knowledge towards commercial ends. In addition to ensuring an effective transfer channel for academic knowledge to industrial purposes, collaboration in these programs involves people from both sides of university–industry boundary in the collaboration and thus facilitates new forms of collaboration and trust building.

Technology Innovation Management Review June 2018 (Volume 8, Issue 6)

How Doctoral Students and Graduates Can Facilitate Boundary Spanning between Academia and Industry

Leena Kunttu, Essi Huttu, and Yrjö Neuvo

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Technology Innovation Management Review June 2018 (Volume 8, Issue 6)

How Doctoral Students and Graduates Can Facilitate Boundary Spanning between Academia and Industry *Leena Kunttu, Essi Huttu, and Yrjö Neuvo*

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Involving customers and users in university-industry collaboration

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Abstract: High-technology firms are increasingly engaging in collaborative relationships with universities to transfer academic knowledge for industrial purposes or to jointly develop valuable new knowledge. The university-industry collaboration typically focuses on the early stages of a product development process, where new ideas and innovations are being developed. On the other hand, the interaction between the firm and its customers takes place during the commercialization of new innovations. For this reason, customer insights should be included to a greater extent in university-industry collaboration projects. Based on a case study comprising five long-term university-industry collaborations in Finland, this paper demonstrates how the involvement of end users and industrial customers in university-industry collaborations can contribute to both the early and late phases of the product development process. This paper highlights the collaboration practices involving end users and customers that facilitate the commercialization of the university-industry collaboration.

Keywords: Commercialization, university-industry collaboration, customer involvement; user involvement.

1 Introduction

In the spirit of open innovation (Tether and Tajar, 2008; West *et al.*, 2014) technology firms are nowadays augmenting their research and development (R&D) capacity by collaborating and co-developing with other players and institutions. This trend has also stimulated the growth of university-industry collaboration (Morlacchi and Martin, 2009), and technology firms are increasingly absorbing and exploiting the results of academic research through collaborative university-industry relationships (UIRs) (Perkmann *et al.*, 2013; Ankrah and AL-Tabbaa, 2015). Consequently, the research partnerships between industrial firms and universities enable the firms to absorb new knowledge that may be critical for their R&D activities, to solve technological problems and to gain access to

critical human resources and new competences (Lee, 2011). For this reason, R&D management of technology firms seek guidance on "best practices" related to strategies and incentives as well as measuring and monitoring the commercialization of university-based innovations in technology firms, particularly those operating in knowledge-intensive high-technology areas (Phan and Siegel, 2006). However, to achieve the desired results of innovative UIR collaborations, firms must be able to commercialize the results of the collaboration (Thursby and Thursby, 2000). This has often been shown to be unexpectedly difficult. One obstacle to commercialization of the UIR collaboration results may be the fact that the UIRs form a complex set of overlapping interactions and institutions (Laursen and Salter, 2004; Siegel *et al.*, 2004) with relatively high organizational and cultural barriers (Bruneel, D'Este and Salter, 2010). Whereas the industrial firms mainly focus on utilization of short-term research that directly contributes to their R&D and product innovations, universities often act as open and social institutions that primarily focus on creating public knowledge and education (Bruneel, D'Este and Salter, 2010; Lee, 2011).

The importance of the commercialization of the results of collaboration with university research has been recognized in many academic studies in this field (Siegel *et al.*, 2004; Perkmann *et al.*, 2013; Weckowska, 2015), but few studies have actually explored what kinds of practices could facilitate this commercialization in terms of organizational learning (Weckowska, 2015). In this study, the focus of the research lies in the involvement of users and customers in UIR collaborations. Several studies have explored and highlighted the facilitating role of customer involvement in improving R&D performance and innovation (Gruner and Homburg, 2000; Un, Cuervo-Cazurra and Asakawa, 2010) in high-technology firms. However, previous research has not studied what kind of role the customers and users may play in the commercialization process of university-industry collaborations. This paper aims to address this gap seeking to answer to the following research question: *How can customer and user involvement in UIR collaboration facilitate commercialization of the collaboration results?* By seeking answers to this question, the study examines the practices related to customer and user involvement in successful UIR commercialization processes, through a multiple case study of five UIR cases in Finland. The practices related to customer involvement are examined in terms of inductive, qualitative research, which is useful in this context since it enables the researcher to analyse the organizational practices related to stakeholder collaboration based on interview data.

2 Background

Acquiring new state-of-the-art knowledge for a new product development process is a central challenge for firms operating in high-technology areas. To stay ahead of their competitors in terms of innovation performance and product development outcomes, the firms must search for this knowledge outside their boundaries (Asakawa, Nakamura and Sawada, 2010). Thus, collaboration with a network of different external partners and stakeholders has become crucial, and firms are actively exploring opportunities for collaborations in relationships with external partners (Emden, Calantone and Droge, 2006). In the research collaborations carried out in UIRs (Perkmann *et al.*, 2013; Ankrah and Al-tabbaa, 2015), the industrial actors share and jointly develop new knowledge with

their university partners (Kunttu, 2017). The academic involvement in the UIR collaboration typically contributes to the early stages of industrial firms' product development processes (Gruner and Homburg, 2000), as presented in Figure 1. This is because academic involvement in industrial projects often generates new ideas, but the commercialization of the UIR innovations has traditionally been executed as an internal industrial process, not usually involving research partners. On the other hand, industrial firms often involve their customers and end users in the final stages of product development, e.g., in piloting or testing newly developed products or services (Gruner and Homburg, 2000). In this manner, customer involvement in product development usually focuses on the incremental improvement of current products, not on generating new ideas and possibilities for future products (Danneels, 2003, 2004; Un, Cuervo-Cazurra and Asakawa, 2010, p. 687). Moreover, (Gruner and Homburg, 2000) have suggested that a firm's collaboration with customers best contributes to new product success when customers and users are involved in the later stages of the product development process, especially product testing activities – stages that are directly related to commercialization (Figure 1). However, as indicated by (Gruner and Homburg, 2000), customer involvement could also potentially contribute to the earliest stages of the product development process in terms of generation of ideas, if this kind of interaction is correctly facilitated. The purpose of this paper is to investigate how customer and user interaction with industry could be combined with the academic interaction taking place in UIRs, and how these two types of interaction could jointly contribute to industrial product development and commercialization.

This paper analyzes the role of user and customer involvement in UIR collaboration and in particular their impact on the commercialization process of the outcomes of this collaboration. Since the customer relationships can be seen in two distinct ways: relationships with B2B (business-to-business) customers and direct relationships to end-users (B2C, business-to-customers), these customer relationship types are being analyzed separately. The first group of customer relationships, *customers*, includes the firms who are the industrial partner's B2B customers. Involving customers in R&D collaboration (Cohen, Nelson and Walsh, 2002) helps the collaboration partners to understand customer preferences and needs, which in turn contributes to the joint innovation process between the collaboration partners (Un, Cuervo-Cazurra and Asakawa, 2010). The second stakeholder group, *end-users* of the industrial firm's products represent the consumers, who may provide the collaboration partners valuable, experience-based knowledge on the usage of the products. Understanding the end-user expectations, needs and favors is essential for companies who provide products and services for consumers.

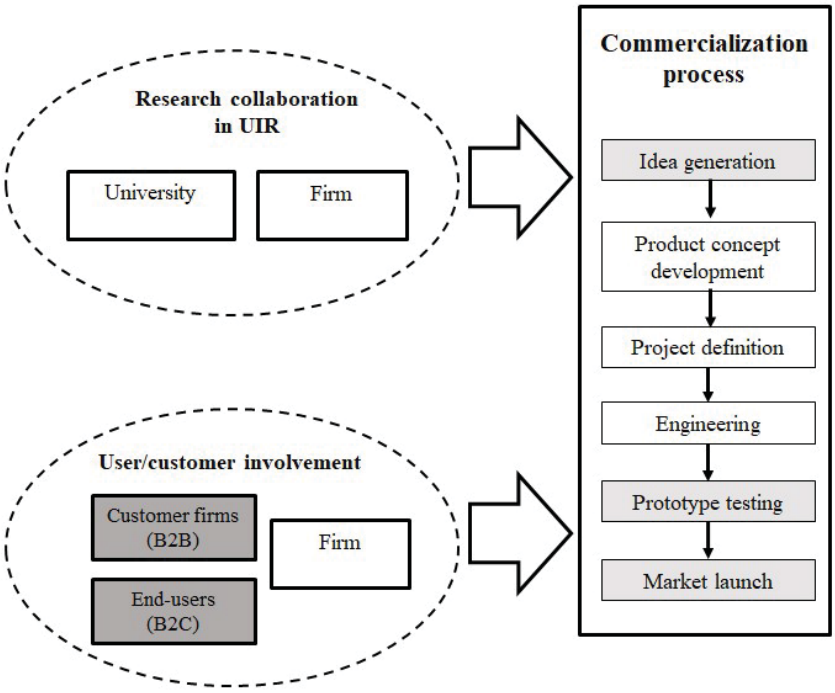

Figure 1 Industrial firms' product development process. University collaboration taking place in UIRs typically contributes to the early stages of the process whereas the main focus of customer involvement lies in the final stages of the process.

3 Case study

To explore what kinds of organizational practices may facilitate the successful commercialization of the results obtained in the university-industry collaboration, a comparative, qualitative case study of five companies actively collaborating with universities in Finland was examined. The main data collection method in the case data acquisition was interviews, but additional secondary data such as corporate brochures and archives, Internet information and descriptions of the partnership were used. The cases for the case study were selected in a purposive manner to find long-term and close collaborative UIRs that had yielded to successful results in terms of commercialized results of the collaboration. In addition, all the selected cases, the customers or users of the industrial partner were involved in the UIR collaboration. For the case interviews, a semi-structured interview template was designed and utilized. The template focused on the commercialization process by asking the interviewees to tell about the process that yielded to successfully commercialized innovations in the UIRs they were dealing with. A special focus in the interviews was in the involvement of the industrial firms customers in the UIR. The interviewed industrial managers named their key collaborators on the university side, who were usually the leaders of research groups. This way, the most appropriate people for the selected case study were involved, such that all the respondents

were key persons in the cases representing the selected UIRs. Interviews were recorded and transcribed. To maintain confidentiality of the interview data, the analysis presented in this paper identifies the interviewees only by position.

Table 1 Case descriptions for the studied relationships between universities and industrial partners

	Case A	*Case B*	*Case C*	*Case D*	*Case E*
Industrial area	Mobile devices	Telecommunications	Heating systems	IT systems for logistics	Machinery for construction and mining
Relationship age	Five years	Three years	Six years	Four years	Six years
Area of the joint R&D projects	Software and algorithms	Service products	Service products	Smart services for logistics	Service products
Stakeholder group involved in collaboration	Users	Users	Users, customers	Customers	Customers
Participants of case interview (industry)	Research Manager	Development director	R&D Director	Global program manager (R&D)	R&D Director

This paper has five cases, as summarized in Table 1. Cases A and B represent cases in which industrial firms collaborate with universities, and this collaboration has a clear and significant involvement of the firms' users (B2C). In cases D and E, the UIR collaboration involves with the firms' customers (B2B). The case C involves both users and customers.

Case descriptions

In case A, a technology firm developing software for mobile devices has close collaboration with its university partner in the area of algorithm development. As user experience is very important aspect in the firm's final products, it had decided to include the user experience analysis to the scope of the joint development project. In practice, this meant that the university partner made user experience testing for the new technologies that they were jointly developing. According to the firm representatives, this kind of joint activity had brought clear additional value to the project results, and also lowered the threshold to commercialize the results of the joint development activities. In case B, a technology firm operating in the area of telecommunications made collaboration with its university partner to develop new services to its users. In this kind of service product development, the role of user experience is essential, and for this reason, the collection and analysis of user experience data of the new services was an important part of collaboration. Also case C presents a UIR collaboration case in which the partners jointly

develop new service products to the firm's end users. The collection and analysis of end user expectations and needs were examined in the beginning of the project, but also in later stage when the developed services were introduced to the users. In this case, the collaboration also involved the analysis and development of the firm's B2B partners, including retailers and service partners. In case D, the company involved some of its key customers in the pilot R&D projects which were relying on long-term research collaboration with an university partner. In this collaboration, the pilot customers tested and verified the results of the research in real circumstances. In the similar manner, case E presents a UIR in which industrial firm's key customer was involved to test and give development feedback on the innovative solutions developed in UIR.

4 Results

Analysis of interviews and secondary data revealed a number of practices for commercialization of UIR collaboration results. This chapter discusses the most prevalent practices, which have been categorized based on three central facilitators of collaboration: industrial partners' customer relationships, academic knowledge and university student work.

Utilizing the industrial partner's relationships to its customers and users in UIRs

Involving customers and users in new product development has been shown to have a clear positive impact on new product success, especially in the final stages of the product development process (Gruner and Homburg, 2000). For this reason, it may be beneficial for the industrial firms to involve their customers and users in the collaborative research process between them and their university partners (Un, Cuervo-Cazurra and Asakawa, 2010), who typically contribute to the early stages of the product development process (Markman, Siegel and Wright, 2008). The role of user involvement in UIR collaboration was analyzed in cases A, B, and C, whereas cases C, D, and E represent customer involvement in UIR research. In all these cases, the collaboration between the firm and university had been developed around a specific product or service development task, and the involvement of users or customers was selected to a key research area of the joint project. The interviewees in cases considering end-user involvement (A-C) described this in the following manner:

> *Our research collaboration started some years ago as a joint research project that contributes to our consumer product development. However, quite soon we understood that it is important for the research project to collect field data from end-users to understand how the users really use our products (IND, A).*
>
> *In our business area, the role of consumer experience is very important. Therefore, it was really good that we could use the consumer data analysis as an input in our university collaboration project that was related to service development (IND, B).*

Thus, the interview data reveals that the firms making research collaboration with universities in the area of consumer products see it important to use end-user information as input in the joint development work. The university researchers also had very positive attitude towards this kind of collaboration but they pointed out that the consumer information could be utilized even more in UIR collaboration, since the analysis of user data also provides the researchers topics for developing scientific outcomes from the collaboration:

> *I feel that consumer and customer involvement fits very well to the scope of our joint development projects with industry. Our industrial partner has been very satisfied with the results of this kind of collaboration, and we as a research institute have been able to utilize the data collected from the users (UNIV, C).*

> *Publishing the research results is often difficult in industrial research projects. However, user experience aspects in these projects are usually not so sensitive to the industrial partners, who often allow us to publish the results related to consumer behavior (UNIV, B).*

According to the interviews, the cases related to the user involvement in the research collaboration projects (A-C) focused on both ends of the product development projects:

> *In our collaboration, we were able to obtain valuable end-user information regarding the usage of our current products as well as ideas for new features to be developed for the future products (IND, A).*

> *Consumer data collected in the project contributed both to the creation and conception of new services as well as improving our current services (IND, B).*

> *In the surveys executed in our university collaboration projects, we collected the user data concerning both feedback on our current products and also obtained ideas for new services to be developed (IND, C)*

Thus, the interview data indicates that when the users are involved in the UIR collaboration, the project may focus on both early stages (idea generation and concepting) and late stages (consumer testing and market launch) of the product development process. The interviewees in cases A-C had quite coherent opinions that this is a clear benefit compared to the traditional UIR research projects that typically involve only with the early stages of the process:

> *When the users are involved in university collaboration, we definitely obtain more concrete research results, which contribute directly to our consumer products (IND, A).*

> *Consumer data was crucial input for our joint development work with university (IND, A).*

In the cases representing customer involvement (C, D, and E), the industrial partners involved some of their key customers to the research collaboration. The main motivation with the industrial partners in this kind of collaboration was to enable smooth commercialization of the technologies that they were developing with universities:

> *Co-creation with our pilot customers is quite active in our own R&D. We have also a long tradition of making research collaboration with universities. In some projects, we have been able to combine these two things, which really helps us to implement the results of research collaboration and test them with the pilot customers (IND, D).*
>
> *We have developed a new technological solution in our joint research project with our university partner. Now, one of our large customers has been involved in this project, and it will test the prototype in its real working environment. Our university partner also collects information on this testing and uses it for further development work (IND, E)*

Thus, the interviews in cases D and E reveal that industrial firms may facilitate the commercialization of the results of university collaboration research by adopting their customers to the final phases of the development process (Gruner and Homburg, 2000). When these "lead customers" test the prototypes together with the firm's R&D and university researchers in real circumstances, the researchers and industrial developers may collect valuable data and feedback on the product usage. This, in turn, helps the collaboration partners to take steps for further development:

> *For us, our university partner contributed our service development work by facilitating interaction with our key customer firms by e.g. interviewing the customer representatives. This has steered the development work a lot (IND, C)*

Thus, the interview data indicates that involving customer firms in university collaboration facilitates the commercialization of the joint development work by means of prototype testing and product validation. This finding is in line with the conclusions of (Gruner and Homburg, 2000), who indicated that the customers' contribution focuses on the latest stages of the product development process. However, the interview data also showed that the customer feedback and involvement has in many cases also impact to the early phases of the process (idea generation):

> *The customer firms have ideas that are related to the improvement of the products by means of new features and properties. The customer interviews made by the university partner helped us to collect and systematically utilize these inputs (IND, C)*
>
> *Sometimes our pilot customers have innovative ideas that may initiate new R&D projects. These projects are typically carried out together with this customer and our university partner (IND, E)*

Combining academic knowledge with customer inputs

One of the researchers' key interest areas in the interviews was to understand the industrial firms' motives to involve their users and customers in the research collaboration with universities. The industrial interviewees agreed that the main benefits for them lies in the academic competences and scientific knowledge that can be complemented with the user and customer experience knowledge that most university partners also possess:

> *When we decided to involve the user experience aspects to our research project with the university scientists, the project team was extended with new researchers who were concentrating on consumer experience. They carried out the user studies related to our project, and we could utilize the results in the project (IND, A).*
>
> *In our research project, we have utilized data collected from both users and customers. In both cases, the university researchers have been in key role, since they have had both scientific understanding and practical skills to make surveys and interviews to our users and customers. They have also analyzed the results and have made good suggestions how to use them in our product and service development (IND, C).*

Thus, the interviews highlight the importance of the multi-disciplinary capabilities of the university research teams: the university partner should be able to provide the industrial collaborate with both technological knowledge and understanding on the user or customer relations. For this reason, the universities have utilized multi-disciplinary teams in their industrial projects:

> *In our research team, the main competence area is technology development. However, we have seen it beneficial to extend our teams with people with background from marketing, consumer interaction or psychology. This way, we can provide our industrial partner an optimal combination of competences for both technological and user experience understanding (UNIV, B).*
>
> *I have seen in many previous industrial projects that pure technological understanding is not enough. For this reason, we have gained competences for e.g. marketing and management in our research team (UNIV, C).*

Whereas utilizing multi-disciplinary university research teams in the collaboration, it is also important that the industrial partners involve cross-organizational teams in the UIR collaboration:

> *We found it important to involve also our marketing people and people responsible for customer relationships in this collaboration. They know the customers best, and they can help the researchers to make contacts to customers. It is also very beneficial to analyze the results of customer studies with them (IND, C).*
>
> *Involving pilot customers in joint research projects means that we involve also our sales department to the project. This way, the university researchers get inputs from both customer, sales and R&D. I think that this is really beneficial (IND, D).*

Employing students and university research staff in customer interface

Experiences on involving university students in research collaboration between industry and academia in terms of innovation and idea generation have been promising (Kunttu,

2017). In all the cases analyzed in this paper, the students have been somehow involved in the joint research project between university, industrial firm and its customers or end-users. The interviewed industrial managers underlined the role of the students in the project, particularly in collecting field data from product users (Cases A-C):

> *In our joint project with university partner, the university students made excellent job when they collected field data from our product users. This way, we were able to get very valuable information on the users' opinions related to the real usage of our products, and in particular to the new features that we were developing (IND, A).*
>
> *The university partner provided us an opportunity to use student groups to make user studies as a part of our larger collaboration project. The groups collected information from our current users and also potential new users, and we really learned a lot of user experience and expectations related to our services. I feel that these findings were one of the key result of the whole collaboration (IND, B).*
>
> *The user studies carried out in different phases of our research project with university really steered the project targets and scope in right direction. At the end of the project, the user feedback collected by the students really helped us to understand the potential of the service products that we had developed (IND, C).*

Again, the interviewees in cases A-C felt it valuable that when working in user interface the students collected data on both early and late stages of the product development process, which confirms our earlier indication about contributing both early and late phases of the product development cycle. In case of customer involvement, the students were involved in case C, whereas in cases D and E, the university research staff was mostly involved in customer interaction:

> *The students made valuable work in interviewing the customers with the university researchers (IND, C).*

Also the university partners appreciated the students' contribution in the research collaboration:

> *I have employed student groups in several industrial research projects. In my experience, one of the most fruitful way of working for students is to operate in the end-user interface. This is probably due to the fact that the students can easily take the position of consumer, and they can also collect consumer information easily from their networks (UNIV, B).*
>
> *Students are eager to contribute to the industrial projects and they are pretty good in making consumer interviews, surveys and other data collection from the field (UNIV, A)*

Table 2 A summary of the collaborative practices

Category:	*User Involvement (Cases A, B, C)*	*Customer involvement (Cases C, D, E)*
1) Utilizing the industrial partner's user/customer relationships in UIRs	- Collecting and utilizing data on the end- user experience within the UIR collaboration projects - Analyzing the consumer behavior aspects in terms of e.g. surveys or interviews	- Collecting and utilizing data on the customer experience within the UIR collaboration projects - Collecting and analysing the data from the joint development work carried out between the firm and its pilot customers
2) Combining academic knowledge with customer/user inputs	-Involving the UIR project with user experience experts having backgrounds in e.g. marketing, psychology, or management	-Involving multi-disciplinary research teams - Utilizing the inputs from the sales department
3) Employing students and university research staff in customer interface	-Employing university students in the field data collection -Utilizing the student's understanding on the consumer behavior	-Employing university students in the collection of the customer inputs in terms of interviews

5 Discussion

The goal of this paper was to investigate the user and customer involvement practices that facilitate the commercialization of UIR collaboration results. In particular, the paper focused on the role of the customers and users as key stakeholders in UIR collaboration. The key practices recognized in this paper are summarized in Table 2. The main findings of the paper were the following. First, the analysis of the five UIR cases showed that involving users and customers in the joint research efforts between universities and their industrial partners clearly helps the partners to commercialize the results of their research collaboration. Involving the users and customers in the collaboration help the UIR partners extend the focus of the joint research also to the late stages, which are directly related to commercialization, as summarized in Figure 2. Second, the user and customer feedback, opinions and experiences represent very important inputs for product development and new product success, and in this sense they are also very valuable inputs for practically oriented UIR research projects. The interview data showed that involving user and customer inputs with academic research capabilities bring clear benefits to the UIR projects, thanks to multi-disciplinary capabilities of the university research teams, who can combine the scientific with understanding on the user behavior

or customer relations. Third, user and customer involvement fits well to university-industry collaboration. This is because universities have good capabilities to interact and communicate with users and customer firms, collect consumer data and make different kinds of user or consumer studies as a part of their research. The interviewed industrial managers appreciated this and agreed that this kind of interaction clearly adds the value of the UIR research collaboration between the firms and universities. The interviews also emphasized the value of university students in the collection and analysis of consumer and customer data.

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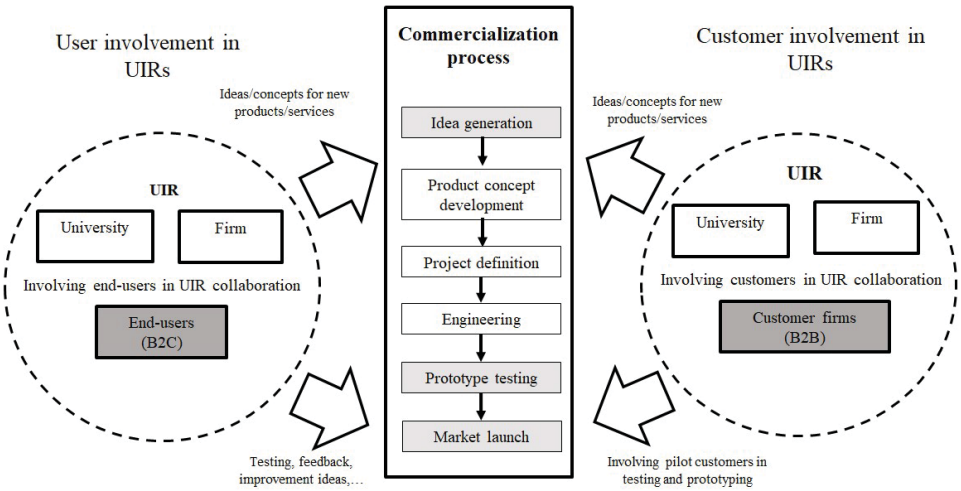

Figure 2 Involving users and customers in commercialization process

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