Vaasan yliopisto
UNIVERSITY OF VAASA

IIVARI KUNTTU

Boundary considerations and joint learning in knowledge-intensive R&D collaboration

ACTA WASAENSIA 378

BUSINESS ADMINISTRATION

ACADEMIC DISSERTATION

To be presented, with the permission of the Board of the Faculty of Business Studies of the University of Vaasa, for public dissertation in Auditorium Nissi (K218) on the 30th of June, 2017, at noon.

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Julkaisija	**Julkaisupäivämäärä**	
Vaasan yliopisto	Kesäkuu 2017	
Tekijä Iivari Kunttu	**Julkaisun tyyppi** Artikkeliväitöskirja	
	Julkaisusarjan nimi, osan numero Acta Wasaensia, 378	
Yhteystiedot Vaasan yliopisto Kauppatieteellinen tiedekunta Johtamisen yksikkö PL 700 FI-65101 VAASA	**ISBN** 978-952-476-750-7 (painettu) 978-952-476-751-4 (verkkoaineisto)	
	ISSN 0355-2667 (Acta Wasaensia 378, painettu) 2323-9123 (Acta Wasaensia 378, verkkoaineisto)	
	Sivumäärä 149	**Kieli** englanti

Julkaisun nimike
Organisaatiorajojen muodostuminen ja yhdessä oppiminen tietointensiivisessä tuotekehitysyhteistyössä

Tiivistelmä
Tämän väitöstutkimuksen tarkoituksena on pyrkiä ymmärtämään kuinka organisaatiorajateoriat selittävät teknologiayritysten tutkimus- ja kehitys (T&K) -toiminnan jakautumista yritysten sisäiseen ja kumppaneille ulkoistettuun työhön. Lisäksi työssä tutkitaan näissä suhteissa tapahtuvaa oppimista ja sen vaikutusta yritysrajojen muodostumiseen.

Työ koostuu neljästä artikkelista. Ensimmäinen artikkeli analysoi T&K-työn organisoitumista teknologiayrityksen toimittajasuhteissa käyttäen teoreettisena viitekehyksenään neljää yleisesti tunnettua organisaatiorajateoriaa, jotka ovat kompetenssi, tehokkuus, voima ja identiteetti. Toinen artikkeli keskittyy yhdessä oppimiseen T&K-yhteistyössä, johon osallistuu sekä yrityksen sisäisiä että ulkoisia kumppaneita. Artikkeleista kolmannen tarkoituksena on varmentaa ensimmäisen artikkelin johtopäätös kompetenssin ja tehokkuuden keskinäisestä positiivisesta yhteydestä T&K-yhteistyössä, ja yhdessä oppimisen vaikutuksesta tähän yhteyteen. Neljäs artikkeli esittelee käytännön päätöstyökalun, jonka tarkoituksena on auttaa T&K-organisaatioita tekemään rationaalisia päätöksiä työn organisoimisesta sisäiseen ja ulkoistettuun työhön.

Väitöstutkimuksen tulokset osoittavat, että organisaatiorajojen muodostumiseen käytännön tuotekehitysyhteistyössä liittyy eri tyyppisiä suhdetason mekanismeja. Yksittäiset organisaatiorajateoriat eivät yleensä riitä selittämään rajojen muodostumista, koska teoriat liittyvät toisiinsa ja niiden keskinäiset riippuvuudet muuttuvat ja kehittyvät pitkäaikaisen yhteistyön kuluessa. Erityisesti suhteessa tapahtuva yhdessä oppiminen vaikuttaa tähän kehitykseen. Yhdessä oppiminen lisäksi edistää yhteistyössä luodun uuden tiedon hyödyntämistä yhteistyösuhteen sisällä.

Asiasanat
Organisaatiorajat, yhdessä oppiminen, tuotekehitysyhteistyö

Publisher
Vaasan yliopisto

Date of publication
June 2017

Autho
Iivari Kunttu

Type of publication
Doctoral thesis by publication

Name and number of series
Acta Wasaensia, 378

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ISBN
978-952-476-750-7 (print)
978-952-476-751-4 (online)

ISSN
0355-2667 (Acta Wasaensia 378, print)
2323-9123 (Acta Wasaensia 378, online)

Number of pages
149

Language
English

Title of publication
Boundary considerations and joint learning in knowledge-intensive R&D collaboration

Abstract

Building on the theories of R&D collaboration, organizational boundaries, and relational joint learning, this dissertation seeks to contribute empirically to this research arena by answering the following research question: How do organizational boundary explanations interplay and coevolve in long-term collaboration partnerships and how does relational joint learning facilitate that development?

This dissertation is composed of four interconnected articles. The first article analyzes the interplay of four organizational boundary theories (competence, efficiency, power, and identity) within the R&D supplier network of a global technology firm. In the second article, the theory of relational joint learning is analyzed in a case study examining relationships between a technology organization and its internal and external R&D partnerships. The third article validates a key result of the first article by means of quantitative research by showing that the relationship between competence and efficiency of R&D relationships is positive and mediated by joint learning. The fourth article introduces a managerial tool intended to support R&D organizations in their outsourcing and partner selection tasks.

The results indicate that there is an extensive set of relational practices and mechanisms that explain the boundary formation between technology organizations and their R&D suppliers. The results also suggest that the organizational boundary theories investigated in this dissertation are connected to each other and coevolve in long-term R&D partnerships. Relational joint learning in particular is able to facilitate this development, and also facilitates the utilization of the jointly developed knowledge in the relationships.

Keywords
Organizational boundaries, relational joint learning, R&D collaboration

ACKNOWLEDGMENT

The journey toward this dissertation work started almost exactly 10 years ago when I joined Nokia Corporation's R&D unit developing new technologies for mobile imaging. There, I had the privilege of working with a number of extremely competent colleagues on developing new technologies that had never been commercialized. Most of my work tasks related to this commercialization process, which involved collaboration with a number of small and large global technology providers, each developing and providing unique and valuable technologies. Very soon I realized that new technological solutions cannot simply be purchased from external suppliers and then commercialized as part of the customer company's products. Instead, the partnerships with external partners provided the customer with sophisticated technologies and know-how that had to be integrated into the customer's products in a long process of joint development, integration, mutual learning, and technology transfer. When this process was successful, both parties learned a great deal and were able to establish a long-term and mutually beneficial relationship.

This journey continued in 2012, when I joined the research staff of the University of Vaasa. The Department of Management provided me an excellent opportunity to conduct research in the area of collaborative processes in R&D supplier involvement; an area that was familiar to me from my previous work. This new research area was an interesting but also demanding challenge for me, since my earlier research was related to a totally different area—image analysis and processing—that used a very different research approach and methodology to this new area. Very soon the idea of working for a second PhD in this research area crystallized, and now, after four years of research this work is ready. This journey to the research tradition of organizational and management sciences applied to a practical and interesting industrial problem field has proved an excellent learning experience in terms of theories, research traditions, and also wholly new viewpoints on this field. This journey has now reached its first main target, but it continues, in one form or another.

A number of colleagues have supported me during this journey. I would like to thank my supervisor, Professor Marko Kohtamäki for guidance in this research field as well as for co-authoring the articles of this dissertation. I am also grateful to my employer, the University of Vaasa, for providing an opportunity to carry out this work in a flexible manner as a part of other research and teaching duties. I wish to thank all my colleagues at the Department of Management for creating a good, friendly, and inspiring atmosphere for research and providing me with help

in all small and larger matters that I have encountered during this journey. Among the department staff, I would like to particularly thank Tuomas Huikkola for the excellent collaboration in industrial projects. I am also grateful to Esa Virtanen and Mira Mikkola for their great work in collecting quantitative field data for my research. I would like to thank Andrew Mulley and the Academic Editing Ltd. team for helping with the copy-editing of this dissertation.

I wish also to thank my thesis reviewers, Adjunct Professor Antti Lönnqvist and Professor Saku Mäkelä for their valuable comments and insights that really helped me to improve this dissertation. I am also grateful to my opponent, Professor Pauli Kuosmanen for his interest in this work and encouragement during the whole dissertation process.

This research has been conducted in close collaboration with a number of industrial organizations in the Vaasa region. I am grateful to all the managers and other professionals who have committed their valuable time in meetings, interviews, and discussions related to this research.

This work has been funded by the Funding Agency of Technology and Innovation (TEKES) and DIMECC through two research programs, Future Industrial Services (FutIS) and Services for Fleet Management (S4Fleet). This funding is gratefully acknowledged.

Finally, I would like to express my greatest gratitude to my family, my loving and beloved wife, Leena and our children, Otava and Tähti. Leena, it was actually you who sowed the idea of undertaking this dissertation, and since then you have provided me endless support and encouragement in this work and also offered good advice and inspiration from your own professional experience. You have also been a wonderful mother to our wonderful children, who have taken care of reminding us of what is really important in life. You three are my rays of light, and nothing really important happens without you.

In Vaasa, May 2017

Iivari Kunttu

Contents

Figures

Tables

Abbreviations

KBV	Knowledge-based view
R&D	Research and development
RBV	Resource-based view
TCA	Transaction cost analysis

Articles

This dissertation is based on the four appended papers:

1. Bäck, M. Kohtamäki, Boundaries of R&D collaboration, *Technovation*, Vol. 45-46, 2015, pp. 15-28[1].

2. Bäck, M. Kohtamäki, Joint learning in innovative R&D collaboration, *Industry and Innovation*, January 2016, pp. 1-25[2].

3. Kunttu, M. Kohtamäki, Relationship between supplier resources and governance efficiency – The impact of learning, *Presented at XVIII ISPIM Innovation Conference*, Vienna, Austria, on 18-21 June, 2017.

4. Kunttu, A managerial decision tool for R&D outsourcing and partner selection in high-technology industries, *Technology Innovation Management Review*, Vol. 7, No. 3, March 2017, pp. 25-32[3].

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1 INTRODUCTION

Not all smart people in the world work for us. We need to work with smart people inside and outside our company.

Henry Chesbrough (2003)

1.1 Background

Research and development (R&D) has been widely adopted as a strategy for innovation, and it has been recognized that collaboration has become crucial for R&D practices in a world where product innovation is increasingly challenging (Emden, Calantone, & Droge, 2006). Accordingly, technology firms today strive to acquire new, state-of-the-art knowledge available outside the firm's boundaries, because they want to stay ahead of the firm's competitors in product development outcomes and innovation performance (Asakawa, Nakamura, & Sawada, 2010; Un, Cuervo-Cazurra, & Asakawa, 2010), and therefore it has become imperative for firms to have the ability to network with other firms to enhance innovation (Dittrich & Duysters, 2007; Duysters & Lokshin, 2011; Nieto & Santamaría, 2007; Powell, Koput, & Smith-Doerr, 1996). Accordingly, in the spirit of the open innovation paradigm (Chesbrough, 2003), technology firms have opened their doors to collaboration with external actors providing valuable knowledge resources, competences, and capabilities (Enkel, Gassmann, & Chesbrough, 2009).

As R&D has been seen as an important driver of competitive advantage for industrial firms (Dittrich & Duysters, 2007; van Echtelt, Wynstra, & Weele, 2007; Verona, 1999), the number of different kinds of R&D partnerships has been regularly growing since the 1960s (Hagedoorn, 2002). There is considerable evidence suggesting that involving external R&D partners extensively and early in product development can improve a firm's performance in terms of productivity, speed, and quality (Johnsen, 2009; Ragatz, Handfield, & Petersen, 2002; van Echtelt, Wynstra, van Weele, & Duysters, 2008). Consequently, firms have extended their product development and innovation work across their boundaries by involving technology partners in their internal R&D work (Johnsen, 2009; Quinn, 2000; Wagner & Hoegl, 2006). This makes it possible for the technology firms to benefit from other firms' resources as well as from other firms' usage of their own resources (Emden et al., 2006). However, having access to valuable external resources alone does not mean that the firm will be

able to fully utilize the knowledge or capabilities provided by the partnership. Instead, innovative collaboration within external partnerships requires firms have the ability to learn and jointly develop new knowledge in the partnership (Hurley & Hult, 1998; Kale & Singh, 2007; Kale, Singh, & Perlmutter, 2000), a capability that enables rapid innovation from external competence and knowledge resources (Davis & Eisenhardt, 2011; Huikkola, Ylimäki, & Kohtamäki, 2013; Un et al., 2010). For this reason, relational joint learning is seen as an essential phenomenon related to successful and innovative R&D collaboration between high-technology firms (Fang, Fang, Chou, Yang, & Tsai, 2011; Kuwada, 1998).

This dissertation concentrates on the R&D collaboration between technology organizations and their R&D suppliers from two separate but related viewpoints. First, the dissertation examines the boundary setting between the focal technology organization and its R&D suppliers from the viewpoint of four organizational boundary theories by analyzing the factors and mechanisms explaining the boundary formation. Second, this dissertation investigates the effect of joint learning taking place between technology organizations and their external and internal R&D partners in long-term collaboration. Based on the outcomes of these two research areas, this dissertation contributes to the literatures on R&D supplier involvement, organizational boundaries as well as relational joint learning.

1.2 Research gap

Managing the involvement of external partners as a part of the firm's R&D activities requires decisions and activities related to coordinating, prioritizing, mobilizing, timing, and informing with regards to the tasks, resources, and responsibilities outsourced from external partners (van Echtelt et al., 2008; Wynstra, Weggeman, & van Weele, 2003). Hence, successful R&D supplier involvement requires firms to develop internal routines and practices to organize the collaboration with suppliers (Mishra & Shah, 2009), and develop competences to do so. Although collaboration across firm boundaries provides the firms with access to valuable sources of knowledge, there are also often challenges in transferring, interpreting, and integrating heterogeneous types of knowledge across organizational boundaries, and a lack of common understanding, different priorities, and coordination problems can impair the efficiency of the collaboration network (Stump, Athaide, & Joshi, 2002; Tortoriello & Krackhardt, 2010). The existing literature on R&D collaboration, which is mainly quantitative, pays relatively little attention to the collaborative

process between customer and suppliers in the R&D relationships (Davis & Eisenhardt, 2011, pp. 160–161). Furthermore, as pointed out in prior research (Johnsen, 2009), there is a need to develop a greater understanding of the characteristics and management of ongoing R&D supplier relationships within and between supplier involvement projects (van Echtelt et al., 2008).

Second, managing supplier involvement in R&D collaboration relationships is closely related to the explanations of firm boundaries (Santos & Eisenhardt, 2005), because the R&D organizations determine their boundaries by deciding which activities, tasks, or projects will be undertaken by the organization itself (hierarchical governance) and which will be outsourced to suppliers (market governance). Previous research in the field of organization studies has suggested four theoretically grounded explanations for organizational boundary formation (Santos & Eisenhardt, 2005). In knowledge-intensive high-technology areas, a firm's capabilities, competences, and technological knowledge play an important role when decisions on boundaries are made (Argyres & Zenger, 2012; Barney, 1999; Jacobides & Hitt, 2005). Therefore, boundary explanations based on the theory of the resource-based view (RBV) suggests firms to improve their competitiveness by maximizing their access to valuable external resources (Lavie, 2006). On the other hand, a strong research tradition relying on transaction cost analysis (TCA) has argued for the importance of transactional efficiency considerations in boundary explanations (Hoetker, 2005; Rindfleisch & Heide, 1997). In addition, the risk considerations related to the resource dependence on external partners caused by technology partnerships (Gulati & Sytch, 2007) have been identified as a remarkable explanation for firm boundaries whereas organizational identity (Kogut & Zander, 1996; Weick, Sutcliffe, & Obstfeld, 2005) may also have a remarkable impact on the boundary decisions concerning the organization of R&D work. Different organizational boundary explanations have traditionally been understood as distinct rationales steering the boundary decisions between internal and external R&D work, and therefore previous studies typically analyze them separately or present them as competing. However, as argued by several scholars (Argyres & Zenger, 2012; Santos & Eisenhardt, 2005), the mutual interplay and interdependence between the organizational boundary explanations is so fundamental that it is better to investigate their interplay and combinations rather than examine them separately. Accordingly, previous literature calls for studies that extend the understanding of the interactions between boundary theories, which in practical collaboration relationships can coevolve and exert a joint impact (Santos & Eisenhardt 2005, p.503).

Third, in knowledge-intensive R&D relationships, the role of joint knowledge creation and learning is essential in the development of new, relation-specific capabilities (Kale & Singh, 2007; Selnes & Sallis, 2003). However, joint learning between R&D partners is not a widely researched topic, despite the fact that learning is an important contributor to creating valuable R&D capabilities and innovation performance in relationships (Davis & Eisenhardt, 2011; Dyer & Singh, 1998; Kale & Singh, 2007; C. Lin, Wu, Chang, Wang, & Lee, 2012). In R&D collaboration, joint learning between partners is particularly important, because it includes processes such as creation and sharing experimentally produced tacit knowledge that is often difficult to transfer or utilize (Chang & Gotcher, 2007; Huikkola et al., 2013; Selnes & Sallis, 2003). Therefore, there is a need to understand the mechanisms and collaboration practices facilitating joint learning and joint knowledge creation in R&D collaboration relationships.

In light of these gaps, this dissertation aims to integrate three streams of research: R&D supplier collaboration, organizational boundaries, and relational joint learning. Doing so improves understanding of the mechanisms and practices of innovative R&D collaboration within supplier–customer relationships. In this research field, this dissertation aims to make several contributions. First, the dissertation contributes to the literature on R&D collaboration by employing firm boundary theories and by examining the interplay and interdependence between different boundary theories in this context. Second, this dissertation complements theories on organizational boundary formation with a relational joint learning approach by showing that joint learning facilitates the link between resources and the transactional efficiency of the R&D relationships. Third, the dissertation extends the prior literature on relational joint learning by analyzing the joint learning mechanisms in internal and external R&D collaboration relationships. Fourth, the dissertation makes a practical contribution by presenting a managerial tool based on organizational boundary considerations to support R&D outsourcing and partner selection decisions in R&D organizations. In sum, this dissertation seeks to lay foundations for future work on explaining the organization of R&D work and steering it toward internal and external tasks, and also on knowledge creation and learning in collaborative R&D relationships.

1.3 Research questions and objectives

The primary objective of this dissertation is to address to the following research question:

How do organizational boundary explanations interplay and coevolve in long-term collaboration partnerships and how does relational joint learning facilitate this development?

This main question is approached by using more specific questions addressed in each article:

Q1. Which practices are related to firm boundary theories, and how do they interplay and coevolve in long-term R&D relationships? (Article 1)

Q2. Which factors in R&D collaboration practices facilitate innovative joint learning in an R&D network featuring internal and external relationships? (Article 2)

Q3. What is the impact of resources provided by the R&D supplier relationship on the efficiency of the relationship, and how does joint learning taking place in the relationship facilitate this impact? (Article 3)

Q4. How to facilitate rational organization of R&D work into internal tasks and tasks to be outsourced to suppliers? (Article 4)

The first research question (Q1) in Article 1 seeks to identify the relational practices and mechanisms of boundary formation between a technology unit and its R&D suppliers by using a qualitative comparative case study examined in supplier relationships of a global technology firm. The article analyzes the interplay between boundary theories in R&D context, and complements them with trust and joint learning approaches. The second research question (Q2) addressed in Article 2 is related to one of the most important findings of Article 1, that is, the central role of relational joint learning as facilitator of efficient long-term R&D collaboration. Accordingly, Article 2 examines the learning related practices and mechanisms in internal and external R&D collaboration relationships of an industrial R&D organization and suggests that the linked role of mutual dependence, embeddedness, and innovation are the main factors behind relational learning process in the R&D relationships. Again, building on the findings of Article 1, the third research question (Q3) addressed in Article 3 aims at validating the positive relationship between RBV and TCA in the R&D relationships in terms of quantitative analysis, which in turn improves understanding of the interplay between these two boundary approaches. The study also confirms that relational joint learning mediates the link between these two approaches, as indicated in Article 1. The fourth research question (Q4) is addressed in Article 4, which presents a managerial outcome of the first article by introducing a practical tool intended to support R&D organizations in their

outsourcing and partner selection tasks. The tool is based on the theoretical framework of organizational boundaries presented in Article 1. Table 1 summarizes the key characteristics of each article.

1.4 Structure of the dissertation

This dissertation is structured in two parts. The first part consists of this introductory chapter followed by a theoretical chapter concerning R&D collaboration, concepts of organizational boundaries and relational joint learning, research methodology, and finally a results and discussion chapter. The purpose of the first part is to outline the theoretical background found in the literature of the research area influencing the dissertation. Part two contains four dissertation articles. Articles 1, 2, and 3 are co-authored by the author of this dissertation and Professor Marko Kohtamäki, whereas the fourth article is sole authored. The author of this dissertation is the lead author in all of the articles and had the main responsibility for data collection, analysis, composing, and writing the articles, and also for managing the review processes.

Table 1. A summary of the Articles of this dissertation.

	Article 1	Article 2	Article 3	Article 4
Focus area	Relational practices explaining organizational boundary formation in R&D collaboration and interplay between boundary explanations	Relational practices and processes that facilitate relational joint learning in innovative R&D collaboration	Verifying the link between resources and efficiency as organizational boundary explanations in R&D collaboration relationships, and the impact of joint learning on this link	Presenting a practical tool for facilitating managerial decision making concerning organizational boundary formation in the R&D context
Theory	Organizational boundaries	Relational joint learning	Organizational boundaries and joint learning	Organizational boundaries
Research strategy	Comparative multiple case study	Comparative multiple case study	Quantitative analysis based on a survey	Multiple case study
Research context	Dyadic R&D collaboration in	Dyadic R&D collaboration in	R&D supplier–customer	Dyadic R&D collaboration in

	a high-technology area (electrical engineering)	a high-technology area (electrical engineering)	relationships in high-technology industry	a high-technology area (electrical engineering)
Data collection methods	Interviews, discussions, secondary sources	Interviews, discussions, secondary sources	Survey	Interviews, discussions, secondary sources
Main findings	1)Mechanisms and factors behind boundary formation in R&D supplier–customer relationships 2) Interaction between boundary explanations in R&D collaboration	1) Facilitators of joint learning in R&D supplier–customer relationships 2) Interlinked process of dependence, embeddedness, and innovation in R&D collaboration	1) Positive impact between RBV and TCA in R&D supplier–customer relationships 2) Mediating role of relational joint learning in this relationship	A managerial tool that enables rational decisions on R&D outsourcing and insourcing and supplier selection

2 THEORETICAL BACKGROUND

2.1 R&D Collaboration

During the last decades, different kinds of alliances have become a central part of technology companies' strategy in terms of competitiveness and growth (Kale & Singh, 2009). These firms have realized that self-sufficiency is becoming difficult in a business environment that demands strategic focus and flexibility (Wittmann, Hunt, & Arnett, 2009; Yasuda, 2005). In addition accessing critical external resources and capabilities has been seen as a primary reason for entering alliances with external partners (Das & Teng, 2000; Yasuda, 2005). In this new way of thinking, relationships are not based on ownership but on partnership (Inkpen, 1996), since the firm might be able to utilize valuable resources by using alliance structures, without possessing them. Hence, strategic alliances that provide firms with an opportunity to leverage their strengths in collaboration with their partners, have become usual.

Gulati (1995) defines a strategic alliance as "a purposive relationship between two or more independent firms that involves the exchange, sharing, or co-development of resources or capabilities to achieve mutual relevant benefits" (Kale & Singh, 2009). Accordingly, a strategic alliance is a form of business relationship that aims to deliver mutual benefit by utilizing the shared resources of the alliance partners. Previous literature on strategic alliances is divided into three main streams (Kale et al., 2000). The first stream attempts to explain the motivational factors related to alliance formation in terms of strategic or resource needs or cost-related rationales (Yasuda, 2005) by way of three viewpoints: strategy, transaction cost theory, and resource-based theory (Kale et al., 2000; Yasuda, 2005) Strategic considerations consider alliance structures as means to improve the firm's strategic position in terms of efficiency or marker power (Ahuja, 2000; Stuart, 2000). Cost-related rationales see alliances as a means to reduce the production and transaction costs of the alliance partners (Dyer, 1996; Williamson, 2008), and transaction cost theory recommends choosing an alliance structure that minimize these costs. The resource-based theory sees firms as bundles of resources, and hence alliances arise when firms complement their own resources with external ones. In the context of resource complementarity obtained by entering strategic alliances, mutual learning, and joint development of new knowledge are central. Therefore, alliance formation can also be viewed as way to learn of and absorb new knowledge, skills, or capabilities from the alliance partners (Kale & Singh, 2007; Khanna, Gulati, &

Nohria, 1998). The second stream of research concentrates on alliance governance structures and the organization of the alliances (Kale et al., 2000). This stream attempts to explain the interfirm linkages and alliances by analyzing the formation, organization, and governance structures of alliances. One set of explanations of alliance structures is focused on the transaction costs associated with an exchange with partners (Rindfleisch & Heide, 1997; Williamson, 1981). Its primary finding is that firms simply use external governance in situations where the costs of doing so are lower than those of internal governance. Another explanation, particularly in high-technology areas, is based on the resource needs of the firms. According to this view, firms form linkages with external partners to obtain access to assets, competences, or skills they require (Parmigiani & Mitchell, 2009; Wittmann et al., 2009), and thus the partnerships provide the firms access to new technologies and know-how previously unavailable from within the firm's boundaries (Das & Teng, 2000). The third stream focuses on alliance performance and effectiveness (Kale et al., 2000). It aims to identify factors that influence the performance of the alliance or the partners in it (García, Sanzo, & Trespalacios, 2008; Mahapatra, Narasimhan, & Barbieri, 2010; Wagner, 2010).

The research questions set in this dissertation are closely related to all three research streams on strategic alliances. From the first stream of research, the strategic and cost efficiency-related one, and also the resource-based reasons, are among the most important explanations of boundary formation in R&D relationships, as examined in the Article 1. Article 2, on the other hand, focuses on relational learning that is an essential motivational factor for alliance formation in the RBV. The second research stream considers the organization and governance structures of the alliances, which are also a central content of Articles 1 and 2 from the viewpoint of relational practices. Related to the third stream, relationship performance and the supplier selection process based on it are topics that are analyzed in a practical manner in Article 4.

2.1.1 Capabilities of knowledge-intensive R&D Collaboration

Knowledge has been recognized as source of organizational competitiveness (Grant, 1996; Spender, 1996; Teece, Pisano, & Shuen, 1997), and interorganizational relationships facilitate the exchange, development and joint creation of new knowledge (Galunic & Rodan, 1998; Weck & Blomqvist, 2008). As technological development and innovation are among primary arenas for competition in R&D-intensive industries (S. L. Brown & Eisenhardt, 1995), the role of knowledge accessibility, knowledge creation abilities as well as

competence considerations are emphasized as facilitators of competitiveness (Kapoor & Adner, 2012; Macher, 2006). Thus, privately held knowledge is seen as valuable resource (Conner & Prahalad, 1996; Galunic & Rodan, 1998), and firms often compete by developing new knowledge more quickly than their competitors (Macher, 2006). Consequently, R&D collaboration networks are often built on knowledge-intensive relationships, in which knowledge is transferred, developed and created between partners. The definitions of knowledge intensity are rather vague in the previous literature, especially when one considers not only formal, scientific knowledge, but also more encultured and embodied versions of it (Alvesson, 2000; Blackler, 1993). However, it has been conceptualized as the output of a joint activity that relies on a substantial body of complex knowledge (Ritala, Hyötylä, Blomqvist, & Kosonen, 2013). Knowledge intensity can be seen as a characteristic of an organization by practices, routines and equipment (Starbuck, 1992), or on individual level by competent individuals acting on different levels of organization (Alvesson, 2000; Ritala et al., 2013).

R&D collaboration refers to complex services offered and exchanged, including product design, feasibility studies, usability analyses, prototype development, and testing, manufacturability analyses, and product customization (Huikkola et al., 2013). Accordingly, R&D collaboration with external partners can provide a firm with the resources, knowledge, and technological expertise it lacks, which in turn can have a positive effect on innovativeness (Dittrich & Duysters, 2007; Faems, De Visser, Andries, & Van Looy, 2010; van Echtelt et al., 2008). Defined as the "capacity to introduce some new process, product, or idea in the organization" (Hult, Hurley, & Knight, 2004; Hurley & Hult, 1998) innovativeness is largely dependent on accumulated and jointly-created knowledge, shared experience, and a joint learning process taking place between the partners to R&D collaboration relationships (Fang et al., 2011; Hoecht & Trott, 2006; Nieto & Santamaría, 2007). However, in addition to innovation, collaboration with external partners tends to be beneficial for technology firms in several other areas (Un et al., 2010). For example, both the firm and its external partner benefit from the access to complementary resources and capabilities without the need to develop them internally or acquire the partner (Un et al., 2010, p. 674). In addition R&D collaboration can improve R&D performance in terms of reduced costs and time as well as improved quality (Ragatz et al., 2002).

High-technology firms often operate in the dynamic environments characterized by strong competition, rapid changes, accelerating product life cycles, changing customer expectations and product discontinuities (Marsh & Stock, 2003). To successfully develop and sustain their competitiveness under these

environmental circumstances, firms need to develop dynamic capabilities that enable them to draw on, to extend and redirect their technological capabilities and R&D resources (Marsh & Stock, 2003). Dynamic capabilities have been defined as: "The firms' processes that use resources—specifically resources to integrate, reconfigure, gain, and release resources—to match and even create market change. Dynamic capabilities thus are the organizational and strategic routines by which firms achieve new resource configurations as markets emerge, collide, split, evolve, and die." (Eisenhardt & Martin, 2000; Teece et al., 1997). Accordingly, dynamic capabilities represent organizational processes by which the organizational actors employ their resources to develop new value creation strategies (Marsh & Stock, 2003; Teece et al., 1997). Creating and maintaining resources provided by interorganizational R&D collaboration networks can be an important dynamic capability in supplementing the internal product development activities of technology organizations (Blomqvist, Hara, Koivuniemi, & Äijö, 2004). In the collaborative relationships between technology firms and their R&D suppliers, cross-functional, and cross-organizational teams and routines for product development, joint knowledge creation and knowledge transfer are identified as important elements of dynamic capabilities facilitating successful R&D and innovation development (Eisenhardt & Martin, 2000).

2.1.2 R&D Supplier involvement

A technology alliance between a focal firm and its R&D partners can be defined as a "formal arrangement between otherwise independent firms that pool together technological resources" (Faems et al., 2010). These collaborations can take place in the relationships between a product development organization's relations with its R&D suppliers (Johnsen, 2009; Quinn, 2000; Wagner & Hoegl, 2006), customers, or users (Al-Zu'bi & Tsinopoulos, 2012; Menguc, Auh, & Yannopoulos, 2014; Wagner, 2010), universities or research institutes (Laursen & Salter, 2004; Perkmann et al., 2013), and even potential or existing industrial competitors (Chuang, Morgan, & Robson, 2014). Based on the previous literature, there are several reasons behind the finding that the technology organizations are able to improve their innovation and R&D capabilities by utilizing interorganizational collaboration networks and partnerships (Faems et al., 2010; Faems, Van Looy, & Debackere, 2005). First, collaboration provides the firms with access to complementary assets that can be used to develop commercially successful and innovative products and services (Teece, 2006; Verona, 1999). Second, working in collaboration with external organizations facilitates and encourages the transfer of valuable knowledge that is often tacit and codified (Galunic & Rodan, 1998; Lambe, Spekman, & Hunt, 2002; Tsai,

2001). This, in turn, helps develop relation-specific resources and capabilities that would otherwise be difficult to develop (Das & Teng, 2000; Wittmann et al., 2009). Third, interorganizational R&D collaboration is able to help to spread the costs of product development among different parties in the collaboration network (Hagedoorn, 2002; Veugelers, 1997), resulting in a notable reduction of the risk related to innovative R&D projects.

In this dissertation, the focal area of interorganizational R&D collaboration is the relations between technology organizations and their R&D suppliers. This field of research is referred as R&D supplier involvement, and it has been greatly expanded during last 30 years. The main reason for that might be the fact that an increasing number of technology firms have outsourced parts of their product development activities to suppliers (Johnsen, 2009; van Echtelt et al., 2008). Previous literature offers several definitions of R&D supplier involvement. Fundamentally it concerns the integration of the capabilities that suppliers can contribute to the customer organization's R&D projects (Dowlatshahi, 1998). According to the definition of (van Echtelt et al., 2008, p. 182), R&D supplier involvement "refers to the resources (capabilities, investments, information, knowledge, ideas) that suppliers provide, the tasks they carry out and the responsibilities they assume regarding the development of a part, process or service for the benefit of a buyer's current or future R&D projects." The interaction between customer and R&D suppliers can range from screening the supply base for new technologies and innovations or consultations with suppliers, to making suppliers fully responsible for the design of the customer's products (Wagner, 2010) Previous research has shown that there are certain benefits for the customer firms in involving suppliers in R&D activities rather than working independently in the central areas of R&D. These benefits include improved innovative performance, better time-to-market or quality, or reduced R&D costs or risks (Wagner, 2010; Wagner & Hoegl, 2006).

2.1.3 Explanations for technology alliance formation

As described in the first section of this chapter, in addition to the expectations of strategic benefits such as competitive advantage, shared risks, new markets, or other market benefits, the main motivational reasons for firms to enter into alliances with external partners are based on two primary explanations, the resource-based theory and the transaction cost approach (Kale et al., 2000; Yasuda, 2005). The resource-based theory explains R&D collaboration with technology suppliers as the employment of external technological resources, skills, and capabilities. Accordingly, the customer organization benefits from the

collaboration with suppliers, by obtaining access to external specialized, complementary resources that it lacks, and which would be difficult to develop internally. This is particularly important in the high-technology areas of rapid technological changes and increased complexity of products (Daniel, Hempel, & Srinivasan, 2002; Yasuda, 2005). The transaction cost theory in contrast holds that firms choose to utilize external R&D capabilities if the cost required for joint development and the relationship governance is lower than the cost of their own, internal R&D (Yasuda, 2005, p. 766). Managing the collaborative relationships with R&D suppliers is a challenging task for the customer organization, since it involves decisions and activities related to coordination, information sharing, problem solving and negotiations with regards to the tasks, projects, responsibilities, and resources (Wynstra et al., 2003). For this reason, the transaction costs related to management, coordination, problem solving, and information transfer can be significant in comparison to the costs related to internal R&D (Yasuda, 2005). However, in successful R&D alliances, the collaboration with competent suppliers tends to yield reduced development costs, which in turn favors outsourcing, also from the viewpoint of transaction cost.

2.1.4 Supplier relationship development

Supplier relationship development and adaptation between R&D partners includes a wide range of factors concerning the long-term process of mutual integration (Johnsen, 2009). The suppliers have to adapt to their customers' internal R&D working procedures and processes. These kinds of partner-specific adaptations are based on previous experiences of joint collaboration between partners, and therefore they facilitate effective future collaboration between them (Walter, 2003). Adaptation has the potential to tie the supplier to its customer, which in turn supports interaction and information sharing between partners, improves the efficiency of the relationship, and also creates entrance barriers for competitors (Brennan & Turnbull, 1999; Walter, 2003). The partners' mutual adaptation in the collaboration requires that there is mutual trust and commitment in the relationship (Blomqvist, Hurmelinna, & Seppänen, 2005; Brennan & Turnbull, 1999). Trust has been found to be a complex construct that encompasses the integrity, honesty and confidence that one party places in another (Coulter & Coulter, 2003). Relational trust (Selnes & Sallis, 2003) is defined as the perceived ability and willingness of the other party to behave in ways that consider the interests of both parties, and hence trust is seen as a facilitator of effective collaboration in customer-supplier relationships. Previous research has identified several mechanisms for building mutual trust (Kale & Singh, 2009). An organization is able to build mutual trust by showing that it

trusts its external partners by making unilateral commitments, or voluntarily assuming a vulnerable position in the relationship. An alternative way involves a partner demonstrating its own trustworthiness by scrupulously honoring all commitments by ensuring it can deliver on any actions it commits to. A third driver of interfirm trust is relational capital (Kale et al., 2000), which refers to the level of mutual trust, respect, and friendship that arises in close interactions at the individual level within the relationship between partners.

Previous research has shown that partners in close relationships with high levels of trust actually learn to collaborate effectively by adapting to each other's processes and ways of working (Kale & Singh, 2007; Zollo & Winter, 2002). (Zollo & Winter, 2002) propose that joint efforts dedicated to technology development and knowledge creation in the relationship act as a basis for improving a firm's skills to manage the collaborative relationship more effectively. This learning process is a dynamic capability referred to as alliance capability building—a process through which a firm learns, accumulates, and leverages its alliance management skills and expertise (Kale & Singh, 2007, p. 984). Accordingly, building alliance capabilities requires firms to develop an ability to adapt to the collaboration and learn the collaboration practices within the partnerships.

2.2 Organizational boundaries

As described in the previous chapters, knowledge-based capabilities, and technological know-how are crucial resources for industrial high-technology organizations, who have to continuously build, integrate, and reconfigure internally available resources and the opportunities provided by external actors to address environmental changes and challenges arising from competition (Grant, 1996; Spender, 1996; Teece et al., 1997). Accordingly, R&D organizations have to extend their activities across their boundaries by outsourcing R&D work to their technology partners (Johnsen, 2009; Quinn, 2000; Wagner & Hoegl, 2006). Therefore, making decisions concerning organizational boundaries and deciding which activities are to be performed internally by hierarchical governance, and which are to be outsourced to suppliers by market governance (Pisano, 1990; Robertson & Gatignon, 1998) are essential strategic and operational choices affecting the firms' innovativeness and R&D performance. In general, technology firms have three basic alternatives to access external technological knowledge and capabilities (Lambe & Spekman, 1997; Steensma & Corley, 2001). They can 1) develop technological capabilities internally, 2) acquire another company that already possesses these capabilities, or 3) enter

into a technology sourcing arrangement, which means an alliance between customer and supplier firm (Jacobides & Billinger, 2006). Therefore, if the firm lacks the capabilities necessary to make the technology development internally, and other organizations already have the technology or capabilities to develop it, management can consider external sourcing (Steensma & Corley, 2001). Accordingly, the problem of accessing crucial external capabilities for a firm's technology development leads to a basic question: when should an individual transaction be carried out internally, externally, or through an alliance? (Jacobides & Billinger, 2006, p. 250).

Organizational boundaries are imagined demarcation lines that can be drawn to separate an organization from its surrounding environment (Fiol, 1989), and they are formally defined as "the demarcation between the organization and its environment" (Santos & Eisenhardt, 2005). Accordingly, the boundaries specify how the organization's internal roles and functions may be distinguished from those of external actors. Therefore, boundaries define, and also delimit corporate relationships in terms of autonomy, control and interdependence (Fiol, 1989), and understanding what are the actual factors that determine firm boundaries and the choice between interacting in a firm or a market is one of the most important issues in economics (Lafontaine & Slade, 2007), in which the main function of organizational boundaries has been seen as distinguishing a firm from other separate but related firms, with which the firm collaborates. In this context, the question about determining firm boundaries often involves considerations on what activities the firms govern internally through hierarchical governance and which they outsource from the market (Argyres & Zenger, 2012).

Figure 1 presents an example illustration of the boundary setting. A firm's legal boundary is the demarcation of the firm's internal and external activities, whereas a salient boundary represents the sphere of internal and external activities that are included in the firm's operations, and therefore also contains the activities that are outsourced from external actors. The firm might change its salient boundaries by making decisions on which activities are performed internally based on hierarchical governance, and which activities are performed through alliances with external partners by market governance. The boundary decisions are typically influenced by external forces such as the unpredictability of the operating environment, competition, laws and regulations, and also rapidly changing consumer demands (Rindfleisch & Heide, 1997). Moreover, as industrial managers in charge of the organization of R&D work have to regularly decide how best to utilize an external supplier's resources and simultaneously deploy and develop their firm's own internal product development resources, rational outsourcing, and insourcing decision making is an important topic.

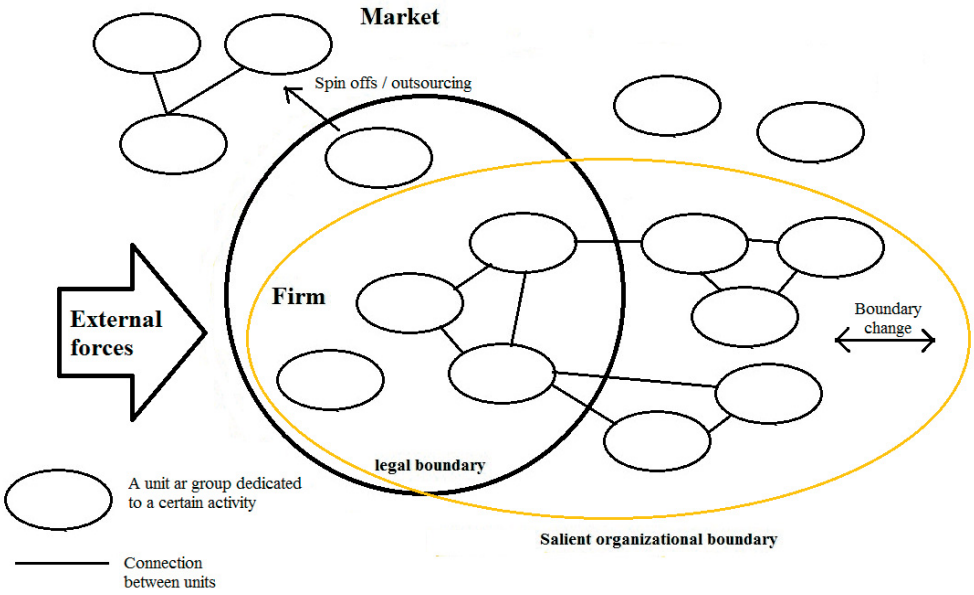

Figure 1. Example image of setting of organizational boundaries.

Scholars have for decades attempted to understand why firms adopt different modes of governance, such as the *make, buy, or ally*? approach. (Coase, 1937) was the first to observe that entrepreneurs and managers make decisions on firm boundaries by considering the benefits of internal production against the costs and risks caused by the use of external partners from the market (Jacobides & Billinger, 2006). Since then, several kinds of theoretical and practical viewpoints have been nominated as theoretical lenses on the topic of organizational boundaries. This dissertation uses a theoretical framework of interorganizational relations to analyze how firms organize and manage R&D in their supplier network. The framework applied consists of four boundary conceptions that are used to study the relationship: efficiency, competence, power, and identity (Santos & Eisenhardt, 2005). Each of these boundary conceptions are presented in the following sections.

2.2.1 Efficiency and transaction cost economics

Coase's (1937) question of *make, buy, or ally?* prompted early empirical studies on firm boundaries to consider individual transactions as a guide to examine decisions concerning buying or making components for manufacturing (Dyer, 1996), comparisons between joint ventures or a fully owned subsidiary (Hennart, 1991) and performing internal product development versus technology partnerships (Pisano, 1990; Robertson & Gatignon, 1998). With the introduction of the theory of transactional cost analysis (TCA) (Williamson, 1981), the

transaction-based firm boundary explanations were based on the argument that the precise terms of transactions between customer firms and its external partner are costly to define, monitor, and enforce, which in turn leads to incomplete contracts between those partners (Santos & Eisenhardt, 2005). Therefore, the choice between hierarchical governance and market governance should be based on minimizing these transactional costs (Argyres & Zenger, 2012; Rindfleisch & Heide, 1997), Accordingly, internal hierarchical governance was seen as preferable to market governance in situations where transaction costs are high enough to exceed the cost advantages provided by market governance (Rindfleisch & Heide, 1997; Williamson, 1981). In the efficiency conception of the organizational boundary explanation, transactional costs caused by the governance of activities are central (Santos & Eisenhardt, 2005). As these costs are different when the activities are outsourced to external markets from the costs caused by internal governance, this conception suggests that *the boundary should be set at the point that minimizes the governance cost* (Rindfleisch & Heide, 1997; Santos & Eisenhardt, 2005), as illustrated in Figure 2. For example, the costs caused by negotiation, execution and monitoring the agreements between partners are a remarkable part of transaction costs taking place in the relationships between firms (Rindfleisch & Heide, 1997). In addition asset specificity, the extent to which one party's investments in the specialized assets that are dedicated to the transactions in the relationship with the other party (Dyer, 1996; Zaheer, Mcevily, Perrone, & Barney, 1998), has an impact on the transaction cost, since the firms have to safeguard their partnership-specific investments (Williamson, 1981; Zaheer et al., 1998).

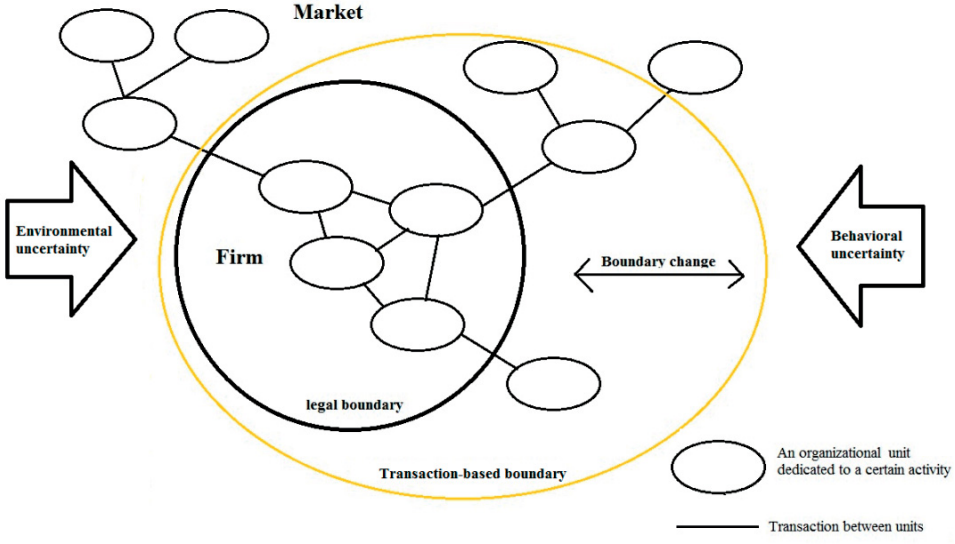

Figure 2. Boundaries of efficiency are set at the point of minimum cost by comparing the costs of internal and external governance.

This kind of safeguarding problem can arise when a firm deploys specific assets and fears that its partner can opportunistically exploit those investments (Rindfleisch & Heide, 1997). Different types of uncertainties are important transaction attributes that have also been argued to reduce the efficiency of market governance relative to internal, hierarchical governance (Santos & Eisenhardt, 2005). Environmental uncertainty refers to the unanticipated changes in circumstances surrounding an exchange between a firm and its external partner, and it is caused by unpredictability of the operating environment (Rindfleisch & Heide, 1997). This is typical in rapidly changing business areas such as high-technology consumer products in which consumer trends can vary rapidly (Heide & Weiss, 1995), and where environmental changes can lead to costs arising from communicating new information, renegotiating agreements, or taking coordination actions to reflect new circumstances (Rindfleisch & Heide, 1997). Behavioral uncertainty, in turn, is caused by the fear of opportunistic behavior of the other party to the relationship (Dyer, 1996), and the partners have to control and safeguard their relationship-specific investments and assess the performance of their transaction partner (Rindfleisch & Heide, 1997). Therefore, transaction cost theory suggests that firms should internalize those activities that are vulnerable to market opportunism (Argyres & Zenger, 2012; Williamson, 1981). The benefits of the internal hierarchical governance model in this context include the fact that internal organizations have more powerful mechanisms to control and monitor activities by measuring and incentives, and internal organizations are capable of providing long-term rewards, such as promotion opportunities (Rindfleisch & Heide, 1997). This way, internal organization enables better managerial oversight and allows better aligned incentives to motivate desired behavior (Santos & Eisenhardt, 2005; Williamson, 1981).

Relationship governance costs can also arise from knowledge and information transfer problems in the relationship (Rindfleisch & Heide, 1997; Santos & Eisenhardt, 2005; Williamson, 1981). These difficulties can occur as information asymmetries owing to partners protecting information that they feel is valuable to themselves or opportunistically sharing sensitive information in the relationship. Information transfer problems can also occur in cases where partners provide the other party with information or knowledge in a form that cannot be utilized or integrated by that party, meaning the partners are likely to have different views on how to accomplish the tasks (Conner & Prahalad, 1996). This, in turn, generates coordination costs in the relationship, especially in an environment marked by high uncertainty (Santos & Eisenhardt, 2005). Typical

mechanisms utilized to manage information problems in the relationships between partners include the development of project management, monitoring, and communication practices, as well as processes and agreements (Rindfleisch & Heide, 1997).

The literature on efficiency conception suggests that this boundary conception is most applicable in the industries that are characterized by intense price competition and a stable structure (Santos & Eisenhardt, 2005). This is because in these less dynamic business environments, the transaction attributes such as asset specificity, information asymmetries and different kinds of environmental and behavioral uncertainties are likely to be fixed through the identification of optimal governance mechanisms, adaptation, and partner selection based on cost minimization (Santos & Eisenhardt, 2005). Nevertheless, high-technology industries usually represent dynamic environments of high environmental uncertainty. It is typical that in these kinds of dynamic environment market requirements, competition and speed of technology renewal (Heide & Weiss, 1995) necessitate a constant need for developing and sustaining product innovation capabilities. Therefore, in dynamic environments, the value of knowledge resources and special, unique competences (Lambe et al., 2002; Wittmann et al., 2009) available in R&D partnerships are emphasized and dynamic capabilities of the collaborative R&D relationship become crucial (Teece et al., 1997). However, also in these relationships the role of governance efficiency is central in several areas. First, in knowledge-intensive relationships, the role of information transfer between partners is crucial, and any difficulties caused by information asymmetries between partners increase the costs of the governance of the relationship (Rindfleisch & Heide, 1997; Teece, 2007). Information sharing issues are closely related to the meeting practices in the relationships, since finding a common understanding and solving any problems in a collaborative relationship requires discussion and close interaction between partners (Kogut & Zander, 1996). Detailed interactions and active information sharing facilitate the joint sensemaking that is required for knowledge creation between collaboration partners (Huikkola et al., 2013). Second, to ensure seamless joint action in the relationships, the partners have to agree on partnership-specific practices. As described earlier, the suppliers have to adapt to the customer's internal R&D processes, tools, and way of working (Walter, 2003). Adaptation facilitates interaction and information sharing between the partners, which in turn improves the efficiency of the relationship (Brennan & Turnbull 1999; Walter 2003). The partners' mutual adaptation in the collaboration with each other requires there to be mutual trust and commitment in the relationship (Brennan & Turnbull, 1999). Trust is seen as a primary facilitator of governance efficiency, since it reduces behavioral uncertainty in the collaborative

relationship (Gulati & Sytch, 2008; Rindfleisch & Heide, 1997; van Echtelt et al., 2008). Third, the role of written agreements is also closely related to the governance costs in the relationship between technology partners (Leiblein & Miller, 2003; Rindfleisch & Heide, 1997). In addition, in this context the role of mutual trust in the relationship is essential, since in mature relationships encompassing high levels of trust, the need for written agreements is reduced. This, in turn, improves the governance efficiency by reducing the transaction costs associated with negotiating and writing agreements between partners (Dyer & Chu, 2003; Leiblein & Miller, 2003; Zaheer et al., 1998).

2.2.2 Competence

Whereas the efficiency conception and transaction cost theory dominated the early research on boundary explanations, during the 1990s several scholars reported on to the limitations of these efficiency-based boundary theories (Jacobides & Billinger, 2006). For example, (Ghoshal & Moran, 1996) and (Kogut & Zander, 1996) suggested that the threat of market opportunism alone is not a sufficient explanation for firm boundaries, and the firms are much more than transactional havens, because they provide organizational backdrops for sharing, developing and applying knowledge (Jacobides & Billinger, 2006; Steensma & Corley, 2001). Therefore, the new thinking on organizational boundaries was based on the idea that the boundaries could be explained by the opportunity to create and sustain competitive advantage through effective coordination of resources (Conner & Prahalad, 1996; Kogut & Zander, 1996). The theory behind this thinking is known as the resource-based view (RBV) (Conner & Prahalad, 1996; Eisenhardt & Schoonhoven, 1996; Lavie, 2006). It suggests that firms seek ways to complement and extend organizational resources with valuable external resources that can be sources of competitive advantage and improved innovation performance (Long & Vickers-Koch, 1995). Accordingly, as firms' resources are heterogeneous, and also imperfectly mobile (Eisenhardt & Schoonhoven, 1996; Lavie, 2006), firms have to complement their internal resources with those available externally. Therefore, from the viewpoint of the RBV, partnerships can be seen as ways to complement and extend the firm's own competences (Parmigiani & Mitchell, 2009), and also to share the costs and risks of innovation projects (Eisenhardt & Martin, 2000). Accordingly, the RBV suggests that firms' resources should be valuable, rare, inimitable, and non-substitutable (VRIN). Accordingly, due to their unique nature, they can lead to competitive advantage and sustainable performance for the organization that can fully utilize them (Santos & Eisenhardt, 2005).

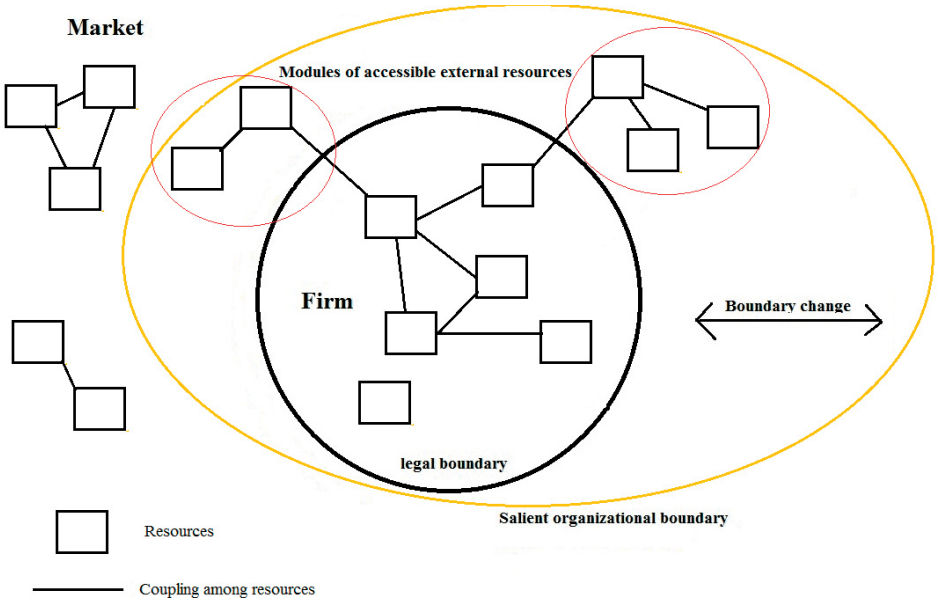

Figure 3. Boundaries of competence are set to the point that maximizes the value of the firm's resource portfolio.

The second conception for organizational boundary setting, competence, is based on the theory of the RBV. In this conception, the organization is conceptualized as a unique bundle of resources (Santos & Eisenhardt, 2005), and it focuses on how organizational members gather, exploit, and renew firm-specific and resource-based advantages by considering the valuable resources, competences, and capabilities owned by the organization. When firms decide to utilize external resources to complement their own competences and capabilities, those external resources can contribute to the focal firm's performance (Gulati, 1998; Lavie, 2006). Accordingly, *the purpose of the boundary formation in the conception of competence is to maximize the value of the resources to which the organization has access* (Figure 3).

In high-technology industries, the role of knowledge is emphasized, and knowledge resources are seen as valuable, since access to external knowledge through relationships has the capacity to improve the firm's innovative performance and thus deliver competitive advantage (Ahuja & Katila, 2001; S. L. Brown & Eisenhardt, 1997; C. Lin et al., 2012). In terms of knowledge-based innovation inputs, firms will look to their partners to provide the resources and technological capabilities they lack and seek to combine the partners' resources and exploit complementarities (Gulati, 1998; Nieto & Santamaría, 2007). Knowledge-based view (KBV) is a theory built on RBV, and which emphasizes the importance of knowledge as a strategic resource and source of competitive advantage (Grant, 1996; Spender, 1996). According to KBV, the differences of

knowledge resources owned by the organizations are able to explain the differences in their performance (Weck & Blomqvist, 2008). Moreover, firms' objectives related to knowledge creation, development and transfer effect on their decisions on how they organize their functions, determine their boundaries (Grant, 1996) and utilize partnerships in technological development (Macher, 2006). According to (Galunic & Rodan, 1998, p. 1194) knowledge resources are typically tacit, context specific, and dispersed. Tacit, experience-based knowledge is difficult to codify into a form that can be easily detected or utilized by outsiders; who lack the experience that has been contributed to accumulate this knowledge (Galunic & Rodan, 1998, p. 1196). Context specificity refers to how contextualized the knowledge resource is, which means that the valuable resource is likely to be of little use outside of the relatively narrow context for which it was developed. Dispersion refers to the extent to which the knowledge is concentrated in the heads of individuals instead of the minds of many (Galunic & Rodan, 1998), which in turn affects the movability this kind of system-embedded knowledge.

Previous literature has shown that dynamic knowledge-based resources enable innovative activities in relationships, but that finding is greatly influenced in practice by a firm's ability to utilize the new knowledge developed in the relationship (Landry, Amara, & Lamari, 2002; C. Lin et al., 2012; Nieto & Santamaría, 2007). Competitive advantage and innovation capability flows not from knowledge resources themselves but from how they are utilized in the organization (Grant, 1996; Weck & Blomqvist, 2008). Accordingly, those firms that have the ability to acquire, assimilate, and exploit the externally available knowledge have better chance of achieving a high level of innovation performance (C. Lin et al., 2012). This ability is referred as absorptive capacity, and is 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, p. 128). Accordingly, organizations that are open to collaboration with external partners and willing to utilize the results of the joint development work, are the most successful in terms of achieving competitive advantage (Ahuja & Katila, 2001; Landry et al., 2002)

In the knowledge-intensive high-technology industries, the external resources utilized by organizations are typically more loosely coupled than in firms operating in less dynamic business environments (Eisenhardt & Schoonhoven, 1996; Santos & Eisenhardt, 2005). In dynamic environments, the value of knowledge resources tends to be emphasized, and hence the dynamic capabilities of partners are crucial (Eisenhardt & Martin, 2000; Teece, 2007; Teece et al., 1997). In collaborative R&D relationships, the role of product innovation

capability is emphasized. That capability is defined as "the ability to pool, link and transform several different types of resources and knowledge to create a solution that is different from existing ones" (Chandy & Tellis, 1998; Menguc et al., 2014). A firm's innovation capability is largely dependent on cumulative knowledge built over many years of experience (Hoecht & Trott, 2006; Nieto & Santamaría, 2007), and therefore close and long-term R&D partnerships in which joint experience is accumulated between partners are seen as very valuable. Therefore, the active involvement of external partners in internal R&D activities brings new, external capabilities, and knowledge into the firm, which is central to the building of innovation capability, especially in those firms that operate in knowledge-intensive high-technology areas (Johnsen, 2009; Wagner, 2010; Wagner & Hoegl, 2006).

2.2.3 Power and resource dependency view

Whereas the competence conception and the RBV view organizations as entities whose success and survival depends on their ability to complement their internal resources with capabilities and skills provided by external partners, organizations can also be seen as vulnerable entities often affected by the uncertainty of environmental factors (Gulati & Sytch, 2007). Accordingly, the third conception for organizational boundary setting, power, considers the dependencies between firms that operate within value systems, and analyzes the ways in which they control the exchange relations they are directly or indirectly involved in (Santos & Eisenhardt 2005). The roots of this conception are in the organizational economics and resource dependency tradition, in which firms are conceptualized as organizations that aim to reduce uncertainty and exercise power over external forces to improve their own performance (Gulati & Sytch, 2007; Pfeffer & Salancik, 1978). According to this boundary conception, the organizational boundaries should be set at the point that *maximizes strategic control over crucial external forces and critical external dependencies*, as presented in Figure 4. In environments where external dependences reduce an organization's bargaining power and also make it more vulnerable to the external actor's opportunism, firms often favor reducing dependence asymmetries in their external collaboration relationships (Gulati & Sytch, 2007), or alternatively evaluate influence mechanisms to increase their control over critical external dependencies (Santos & Eisenhardt, 2005).

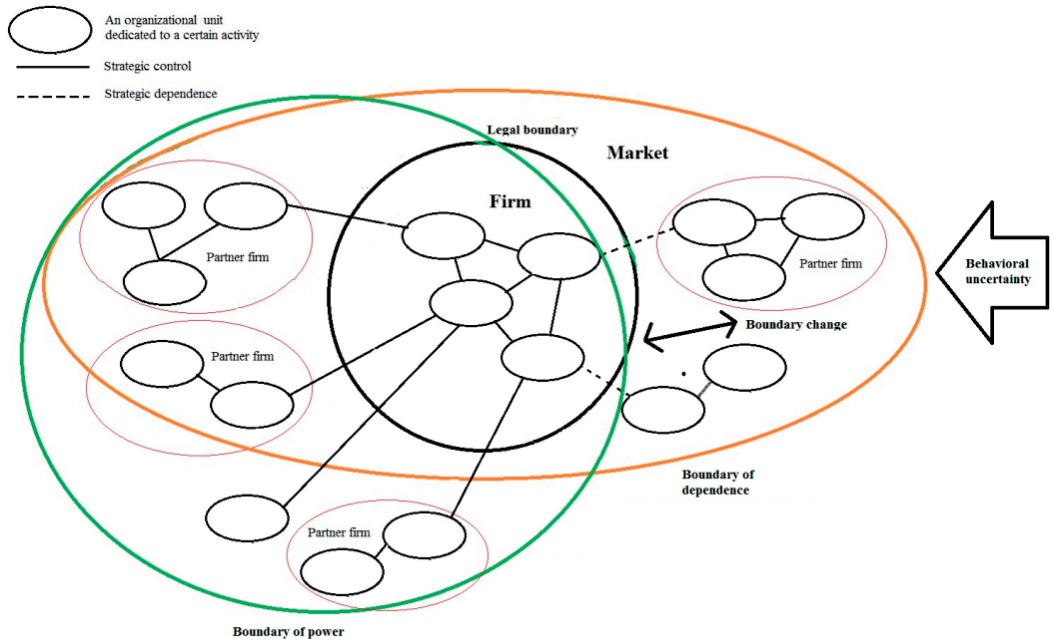

Figure 4. Boundaries of power are set at the point of maximum control over critical external dependencies.

Dependence asymmetry in interorganizational relations refers to differences in the partners' dependence on each other in their relationship. For example, if an actor is more dependent on its exchange partner, that dependence can be constructed as a source of power for the partner. Similarly, if the partner is more dependent, then the actor has the dependence advantage and is thus in a position of relative power in the relationship (Gulati & Sytch, 2007, p. 35). Therefore, increasing power, and reducing dependence in the exchange relationship are seen as two sides of the same coin, since both target having greater control over external forces (Santos & Eisenhardt, 2005). Reducing dependence on external forces is important, since if the organization fails to do so it might be forced to adopt or limit certain activities against its own organizational goals. In a similar manner, if the organization fails to consolidate its power over external forces, it can lose opportunities to enhance its performance by actions such as raising prices or increasing scale (Santos & Eisenhardt, 2005).

In the dynamic environments of knowledge-intensive technology areas, it is usual that firms are dependent on their key partner companies' specialized and unique skills, capabilities and competences (Davis & Eisenhardt, 2011; Roseira, Brito, & Henneberg, 2010; Wagner, 2010). The capabilities of these kinds of partnerships are usually difficult to substitute using other suppliers or to imitate by the customer organization itself in the short term (Gulati & Sytch, 2007). A

customer's commitment to the selected partner suppliers with valuable capabilities make the customer organization vulnerable to opportunistic behavior on the part of the supplier. In addition, relationship-specific investments into the collaboration by both sides to the relationships can make switching partner costly in cases where the customer organization decides to end the collaboration (Heide & Weiss, 1995). Therefore, the costs accruing from partner switching are central when firms consider the risks related to their dependence on suppliers. Because suppliers with special capabilities might be crucial to the customer's R&D performance and innovativeness, customers either have to tolerate dependence on these partners to maintain and sustain their performance (Gulati & Sytch, 2007), or alternatively internalize their strategically important R&D activities to avoid dependence, which in turn means that the customer loses its access to the suppliers' valuable competences (Mayer & Nickerson, 2005).

Previous research has shown that the partners in knowledge-intensive relationships learn to build mutual trust facilitated by relational capital in long-term collaboration (Davis & Eisenhardt, 2011; Lewicki, Tomlinson, & Gillespie, 2006), which in turn helps the firms tolerate dependency in their mature high-technology relationships. Moreover, it is usual in these relationships that the partners are dependent on each other (Gulati & Sytch, 2007). This kind of mutual dependence can lead to the formation of more embedded ties between partners and also the emergence of mutual trust (Gulati & Sytch, 2007, 2008).

2.2.4 Organizational identity

In the identity conception, organizations are conceptualized and defined holistically as social contexts by organizational members' personal and shared interpretations relating to the organization (Santos & Eisenhardt, 2005; Weick et al., 2005). Accordingly the organizational members make boundary decisions by asking *who are we?* and therefore organizational boundaries are set to *achieve coherence between the organizational identity and its activities* (Santos & Eisenhardt, 2005). Accordingly, managerial identity evolves based on the creation of meaning and the development of mental models that define the identity-based boundaries of the organization (Figure 5).

Identity conception emerges from two main theories, managerial cognition, and organizational identity. The first, managerial cognition and sensemaking analyzes managers' cognitive frames that shape their actions (Prahalad & Bettis, 1986; Walsh, 1995; Weick et al., 2005) and the interpretations of their environmental factors (Daft & Weick, 1984). As argued by (Daft & Weick, 1984), interpreting the surrounding environment is a fundamental task for

organizational members, particularly in complex or ambiguous environments. Therefore, collective sensemaking among organizational members can boost their understanding and awareness of new information as well as the meaning of their prior action and of environmental changes (Weick et al., 2005). Accordingly, an organization emerges from its members' sensemaking: "[an] organization is an attempt to order the intrinsic flux of human action, to channel it toward certain ends, to give it a particular shape, through generalizing and institutionalizing particular meanings and rules" (Tsoukas & Chia, 2002, p. 570). Accordingly, organizational sensemaking performed by organizational members can serve to create cognitive frames that serve as information filters for decision making and also reduce ambiguity caused by environmental uncertainty (Prahalad & Bettis, 1986; Santos & Eisenhardt, 2005). When an organization has successfully created cognitive frames, they can be used to guide subsequent actions and decisions by developing cognitive coherence (Walsh, 1995).

The second theory of identity conception, organizational identity helps members to make sense of their position and situation in the organization by clarifying the purpose and direction of the organization. Identity builds on cognitive frames developed through organizational sensemaking (Santos & Eisenhardt, 2005), but these frames are able to shape the identity only when they are shared among organizational leaders and widely communicated in the organization. As the identity reflects the organizational members' shared values and norms that constitute the central and distinctive character of the organization (A. D. Brown & Starkey, 2000; Dutton & Dukerich, 1991; Kogut & Zander, 1996), its roots emerge from several sources. At the inception of the organization, identity was shaped by its founders' beliefs and institutional conditions (Elsbach & Kramer, 1996; Kimberly, 1979). However, identity evolves over time shaped by interactions and among its members, and also with external parties (Porac, Thomas, Wilson, Paton, & Kanfer, 1995) or external institutions (Gioia & Thomas, 1996). Identity-based decisions and actions determine the firm's managerial attitudes and behaviors in interfirm relationships, where the organizational members perceive which are the appropriate courses of action for an organization (Kogut & Zander, 1996; Weick et al., 2005) and thus identity steers decisions concerning organizational boundaries. Organizational members interpret external and internal stimuli by sensemaking aligned with organizational identity (Daft & Weick, 1984; Tripsas, 2009), and managerial actions are then shaped by the process of managerial sensemaking (Walsh, 1995; Weick et al., 2005).

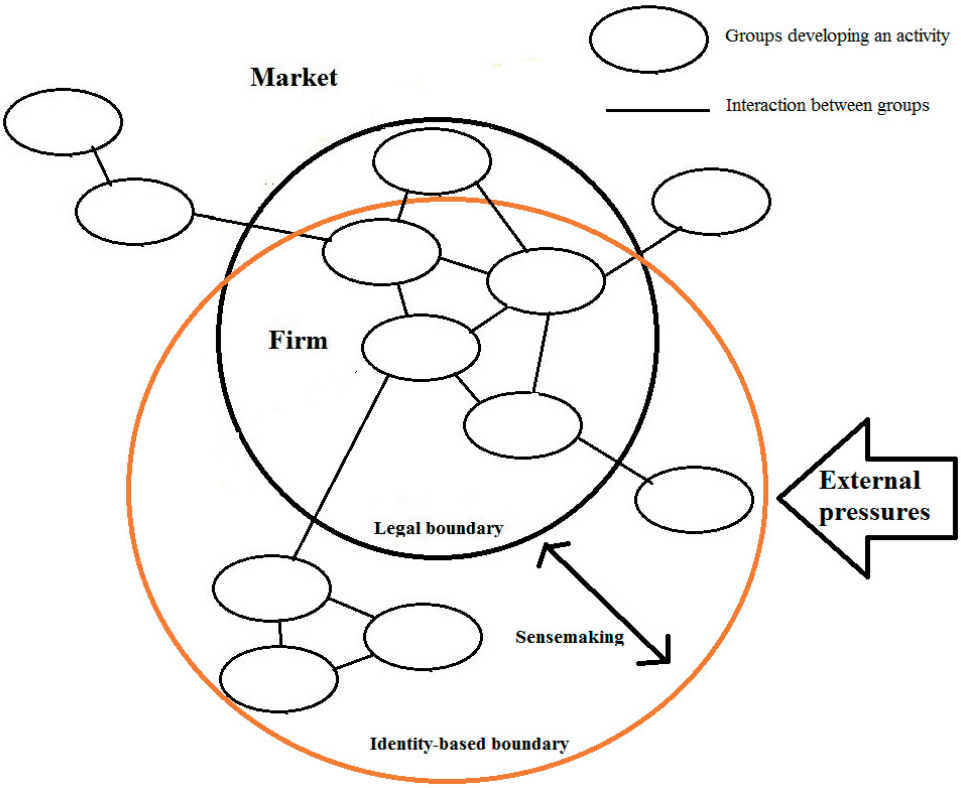

Figure 5. Boundaries of identity are set by resolving inconsistencies between identity and organizational activities.

The literature indicates identity-based boundary conception is a particularly relevant guide for boundary decisions in ambiguous environments, in which environmental uncertainty and rapid changes are typical, and other guides to decision making might not be available (Santos & Eisenhardt, 2005, 2009). In these situations, managerial cognition, and sensemaking might be based on searching for analogies developed elsewhere, which can provide managers with templates of imported identities capable of guiding organizational actions and supporting boundary decisions in ambiguous environments (Rindova & Kotha, 2001; Santos & Eisenhardt, 2005, 2009). This way, identity-based reasoning in organizational decision making can provide the focus and distinctiveness for companies operating on rapidly changing business areas. In addition, hiring new employees, such as senior executives from outside the organization is an important mechanism for changing the identity-based boundaries of the firm (Santos & Eisenhardt, 2005), since the new leader can lead the organization to adopt a new identity that reflects his/her experience and the reality in the business sector concerned (Galunic & Rodan, 1998; Santos & Eisenhardt, 2005). This way of using boundary crossers as a means to alter organizational identity

can be effective in situations when organizational survival is at stake (Siggelkow, 2001).

However, despite these potential competitive advantages, organizational identity can also be a competitive weakness, when managerial decision makers in the organization ignore, reject, or misinterpret the information that might challenge the currently accepted organizational identity (A. D. Brown & Starkey, 2000; Walsh, 1995). Accordingly, identity can often dominate the other boundary decision mechanisms, because information or evidence that challenges the current organizational identity is not easily accepted (Santos & Eisenhardt 2005, p.502; Brown & Starkey 2000). However, clear environmental changes or demands from the market or other external actors can alter the status quo created by the identity accepted by organizational members. This, in turn, can trigger the process of managerial sensemaking and the re-evaluation of organizational identity (Louis & Sutton 1991), leading to the formation of new boundaries (Santos & Eisenhardt 2005, p.502).

2.2.5 Applying different boundary conceptions

In this chapter, four theoretically grounded conceptions for organizational boundaries have been presented, and their central characteristics have been summarized in Table 2. All these boundary explanations approach the role and nature of the organization in different ways and thus apply their underlying boundary theories to their own organizational view. As these boundary conceptions explain the setting of the organizational boundaries from the viewpoint of their own theoretical roots, they are also applied in the organizations operating in different environments. Therefore, it is not logical to compare the conceptions directly against each other, and it is preferable to adopt a contingency perspective by asking “When does each theory apply?” (Steensma & Corley, 2001). As described earlier in this chapter, the efficiency conception and transaction cost approach have traditionally been regarded as the boundary explanations that are most valid in traditional industries characterized by intense price competition and stable operating environments (Santos & Eisenhardt, 2005), such as car manufacturing (Dyer, 1996; Dyer & Chu, 2003), or the trucking industry (Nickerson & Silverman, 2003). This argument is based on the view that in less dynamic environments, it is possible for the customer firms to manage their supply chains to select appropriate partners, find optimal governance and adaptation mechanisms, and hence to effectively minimize the governance costs arising from supplier involvement (Nickerson & Silverman, 2003; Rindfleisch & Heide, 1997; Santos & Eisenhardt, 2005). However, in the

dynamic environments of high-technology industries, this kind of approach is not always possible, and the value of knowledge and capabilities is emphasized over the direct cost of transactions (Yasuda, 2005). Therefore, in the competence conception, and the RBV, the viewpoint is changed from examining individual transactions to the utilization of external resource opportunities that might be crucial to the competitive advantage of the customer firm.

Table 2. A summary of organizational boundary conceptions.

	Efficiency	**Competence**	**Power**	**Identity**
Conception of organi-zation	Governance mechanism relying on monitoring and incentive alignment	A unique bundle of resources configured for competitive advantage	Institution that exercises power over its environment to control external dependence	Social context that is a result of its members' sensemaking
Theoretical roots	Transaction cost analysis (TCA)	The resource-based view (RBV)	Resource dependency tradition	Organizational identity
Salient boundary setting	Transactions undertaken with the organization	Resources to which the organization has access	Domains over which the organization exercises influence	Dominant mindset of "who are we?"
Central goal	Minimizing governance costs of transactions	Maximize the value of an organization's resources by complementing internal resources with market opportunities	Maximize strategic control over external relationships by controlling instances of critical dependence and extending market power	Aligning organizational activities with organizational identity
Operational environ-ment	Traditional industries characterized by intense price competition and stable operating environment	Competitive environments	Regulated, oligopolistic, or ambiguous environments	Complex and/or ambiguous environments

Metrics	Costs caused by negotiation, execution, information sharing, safeguarding and partner monitoring	Valuable competences, capabilities, skills, and knowledge that can enable competitive advantage	Dependence (a)symmetries and influence over external forces Costs caused by partner switching	Managerial sensemaking
Drivers for hierarchical governance	Environmental uncertainty Behavioral uncertainty Information asymmetries	Needs to increase internal competences and capabilities	Vulnerability to the external partner's opportunistic behavior	Activity is aligned with organizational identity
Drivers for marker governance	Cost advantages provided by market governance	Valuable externally available knowledge or resource complementary that can bring competitive advantages	Market governance is possible when the customer is in a position of relative power in the relationship, or there is a dependence symmetry in the relationship (interdependent partnerships)	Activity is not aligned with organizational identity

Accordingly, the competence conception raises the level of the boundary explanation from the transactional efficiency and cost analysis to the resource portfolio owned by the organization. This means that the focus of the competence conception is on more strategic organizational issues of creating and maintaining the firm's resources, which in turn relates to improving and sustaining competitive advantage, profitability, and growth (Santos & Eisenhardt, 2005). In addition, the power conception clearly has a strategic emphasis, in the same manner as the competence conception, since both recognize collaborative alliances between firms as non-ownership mechanisms offering access to influence over external forces (power), and externally available resources (competence) (Santos & Eisenhardt, 2005). However, these two conceptions are optimal boundary explanations in slightly different environments. Competence, which stresses access, possession, and deployment of valuable resource configurations, is relevant in competitive environments. Power emphasizing

control over strategically crucial external relationships to gain influence and reduce dependence, is the most relevant boundary explanation in environments with well-identified and influential players. This means that the power conception can best be applied in regulated, oligopolistic, or ambiguous environments, and also ambiguous or dynamic environments (Santos & Eisenhardt, 2005). The conception of organizational identity is based on the managerial interpretations of operational environments (Daft & Weick, 1984). Therefore, the boundaries of identity are often unconscious boundaries resulting from the sensemaking of organizational members rather than demarcation lines between organizations created and evolved based on a rational evaluation of alternatives (Santos & Eisenhardt, 2005). Since these boundary choices with organizational members' emotional attachment are consistent with organizational identity, they are relatively independent of other boundary choices based on rational reasoning. However, since they are not based on a particular rationale or metrics, they are particularly applicable in environments of high complexity or ambiguity, in which other guides for boundary choices might not be available (Daft & Weick, 1984; Tripsas, 2009; Weick et al., 2005).

2.2.6 Relationships between boundary conceptions

Relying merely on one conception is rarely enough to explain the boundary setting in reality. This is because firms operating in the high-technology arena are today typically facing challenges around how to integrate the valuable external knowledge opportunities provided by suppliers, while simultaneously protecting themselves against supplier opportunism by limiting dependence. At the same time, managers making boundary decisions are under pressure to keep the cost of relationship governing activities low. In the earlier organizational literature, different boundary explanations were traditionally understood as distinct explanations for boundary choices, and researchers attempted to validate single theories such as TCA or the RBV to explain make-or-buy decisions in different organizational contexts, or regarded these theories as competing alternatives when investigating which one was best able to explain the focal boundary choices (Argyres, 1996; Poppo & Zenger, 1998).

However, during the 1990s researchers recognized the complexity of boundary decisions in firms, and also observed that firms actually forge alliances and participate in networks rather than merely making decisions on making or buying (Dyer, 1996; Jacobides & Billinger, 2006; Poppo & Zenger, 1998; Powell et al., 1996). Recently, several scholars have also examined the interdependence and interplay between boundary explanations (Argyres & Zenger, 2012; Poppo &

Zenger, 1998). For example, Argyres and Zenger (2012, p.1) argue in the context of comparing the RBV and TCA: "interdependence between these two boundary explanations is so fundamental that bald statements about the relative importance of capabilities or transaction costs for a particular boundary choice lack a logical basis." Therefore, explaining individual boundary choices should not be based on single theory but rather on the combination of several conceptions. For this reason, exploring relationships among boundary conceptions has been recognized as a new stream of research in the field of organizational boundary theories (Santos & Eisenhardt, 2005).

Table 3 summarizes some major relationships and synergies recognized in the literature between organizational boundary explanations. Efficiency and competence conceptions both assume competitive environments, but competence often dominates efficiency because it has greater strategic relevance (Jacobides & Hitt, 2005). This is particularly remarkable in dynamic environments where valuable resources are more germane than governance cost minimization (Jacobides & Hitt, 2005; Yasuda, 2005). However, efficiency conception has been shown to have synergistic relationship with competence conception in areas such as value chains (Jacobides & Hitt, 2005; Santos & Eisenhardt, 2009) and new industry structures. The synergies can be achieved when firm executives use efficiency-based reasoning to reduce governance costs, and in this way free up resources to deploy and internalize strategically more valuable activities (Santos & Eisenhardt, 2005). An organization might also develop resources and then outsource the related activities of low strategic value and that have low governance costs, which in turn frees internal resources for internalizing activities of higher strategic value (Jacobides & Hitt, 2005; Santos & Eisenhardt, 2009).

When considering the relationship between efficiency and power, it should be noted that these two conceptions should be applied in different environments: efficiency fits a stable industrial structure with strong price competition well, whereas the power conception applies to ambiguous or dynamic environments with well-identified and influential players (Santos & Eisenhardt, 2005). In these kinds of environments, the role of control on strategic relationships is often viewed as more important than the cost efficiency of single transactions. Moreover, strategic relationships include other actors such as complementing firms and competitors, and institutional players such as regulators, not only industry value chain (buyers and suppliers). However, despite the fact that the power conception focuses on more strategic implications for industry control, power, and efficiency can provide similar boundary explanations on single make-

or-buy decisions in stable markets, since from the power view, efficiency is seen as relevant boundary choice (Santos & Eisenhardt, 2005).

Table 3. Relationships (upper corner) and synergies (lower corner) between organizational boundary conceptions.

	Efficiency	**Competence**	**Power**	**Identity**
Efficiency	-	Competence tends to dominate efficiency owing to its greater strategic meaning, especially in dynamic environments	Control of strategic relationships (Power) is often seen as more important than governance of cost efficiency, especially in ambiguous, or dynamic environments with well-identified and influential players	Identity often dominates efficiency-based reasoning in boundary considerations, because efficiency-based boundaries that question taken-for-granted boundaries are not easily accepted among organizational members
Competence	Minimizing governance costs (efficiency) can help the organization to free up resources to invest in strategically valuable new resources (competence)	-	Power view tends to dominate competence-based boundary formation, since the risks of dependence deal with survival, whereas competence mismatches only limit competitive advantage	Identity dominates competence particularly in routine circumstances, since resource, or knowledge opportunities rarely challenge the taken-for-granted boundary settings achieved in managerial sensemaking
Power	Despite different operational environments, power, and efficiency conceptions can often provide similar boundary explanations for single make-or-buy decisions in stable markets	Interdependence between partners can tie the partners closer together and facilitate joint competence development in the relationship	-	Identity often dominates the power conception, particularly in the stable circumstances of slow change

Identity	Identity and efficiency can sometimes together shape the boundaries over time	In knowledge-intensive and dynamic environments, competence and managerial sensemaking (identity) tend to be intertwined in the long term. This, in turn, changes the organizational identity	Unexpected and/or rapid external changes or market demands can force the executives to re-consider their identity-based boundary choices by managerial sensemaking	-

The comparisons between efficiency and identity conceptions in boundary considerations are often dominated by the identity view. This is because a boundary choice that challenges the currently accepted identity is not easily accepted among organizational members, even though this decision could bring clear benefits in terms of improved governance efficiency (Santos & Eisenhardt, 2005). Previous literature has shown that identity-based reasoning and managerial attitudes in firms tend to be so strong that the managers can ignore, hide, or misinterpret evidence on improved efficiency to maintain their current, identity-based organizational boundaries (A. D. Brown & Starkey, 2000; Porac et al., 1995; Tripsas, 2009). However, identity and efficiency can sometimes together shape the boundaries over time, when identity-based boundary choices have enabled an organizational structure of high efficiency (Siggelkow, 2001).

Competence and power conceptions assume complementary operational environments. Competence is the most germane in competitive environments, whereas power is best applied in regulated, ambiguous, or oligopolistic environments. However, both conceptions recognize external relationships as strategic non-ownership mechanisms for accessing resources (competence) or influence (power) over organizational boundaries (Santos & Eisenhardt, 2005). In cases where these two views compete (e.g., when external resource opportunities suggest outsourcing and high dependence suggests internalization), the power view tends to dominate the decision since the risks of dependence deal with survival, whereas mismatches in competences or resources only limit competitiveness (Mayer & Nickerson, 2005). However, in long-term and mature customer-supplier relationships, mutual trust (Gulati & Sytch, 2008; Lewicki et al., 2006) built on close personal relationships can help firms to tolerate dependence on critical suppliers, which in turn favors a competence-based boundary choice between partners (Davis & Eisenhardt, 2011; Gulati & Sytch, 2007). Accordingly, competence, and power can also have synergistic

advantages, particularly in dynamic, knowledge-intensive environments where both special competences and dependence are critical (Santos & Eisenhardt, 2005). In these environments, collaborative relationships are often formed between actors that are dependent on each other (Davis & Eisenhardt, 2011; Gulati & Sytch, 2007). For example, small suppliers possessing special and unique capabilities or competences are often dependent on their main customer, who is, in turn, dependent on the capabilities and competences provided by its supplier (Gulati & Sytch, 2007). In these kinds of relationships, mutual interdependence facilitated by mutual trust can tie the partners closer together and facilitate joint knowledge and competence creation in the relationship (Lewicki et al., 2006).

Identity-based reasoning also tends to dominate boundary considerations based on competence, particularly in routine circumstances. This is because external resource or knowledge opportunities can rarely challenge the emotional status quo and taken-for-granted boundary settings achieved in managerial sensemaking (Santos & Eisenhardt, 2005). However, competence-based reasons can sometimes increase awareness and consistency in the topics of the identity-based questions: *who are we?* or *what we are good at?* particularly in dynamic environments of rapid change and strong competition (Rindova & Kotha, 2001; Santos & Eisenhardt, 2005). Accordingly, as knowledge resources, capabilities, and skills are crucial for firms operating in knowledge-intensive high-technology areas, the competence-based resources, and managerial sensemaking tend to be intertwined in the long term, which in turn changes the organizational identity (Burgelman, 2002). Therefore, competences can act as sources of identity in the organization (Galunic & Rodan, 1998, pp. 1199–1200), which in turn can improve the focus of the organization.

Identity also tends to dominate power conception, particularly in the stable circumstances of slow change (Santos & Eisenhardt, 2005). However, unexpected changes or other extreme circumstances can change the managerial status quo facilitated by organizational identity. For example, when important external actors make demands or actions that are inconsistent with the current organizational identity, managerial sensemaking can be triggered and the organizational identity altered (Louis & Sutton, 1991). Accordingly, environmental changes or demands can force the organizational members to re-evaluate their identity and adjust the boundaries accordingly (Santos & Eisenhardt, 2005). In addition industry norms and categorizations made by investor analysts can be such powerful external constituents that they can force the executives to change their boundaries to align with them (Zuckerman, 2000).

2.3 Relational joint learning in R&D relationships

As described in the earlier sections, high-technology firms often need to complement their internal resources with external capabilities by using their R&D collaboration partnerships as a resource for innovation work (Fang et al., 2011). This kind of networked collaboration is able to provide the firm with the resources, knowledge, and technological know-how it lacks, thus improving its innovation performance (Gulati, 1998; Nieto & Santamaría, 2007; Un et al., 2010). Accordingly, R&D partnerships can be seen as a means to increase firms' internal competences (Parmigiani & Mitchell 2009), and jointly develop technological innovations in the collaboration across organizational boundaries (Powell et al., 1996; Stuart, 2000). This is because innovativeness depends largely on shared experience, cumulative knowledge, and learning taking place in the R&D relationships (Cegarra-navarro, 2007; Fang et al., 2011; Nieto & Santamaría, 2007). Knowledge creation and transfer routines in parallel with cross-functional practices and organizational structures have been viewed as essential elements in this collaboration (Eisenhardt & Martin, 2000). This is because those routines are able to bring new external knowledge and resources into the firm, and also build the internal technological and innovation capabilities that are often crucial in high-technology areas (Johnsen, 2009; Quinn, 2000; Wagner, 2010; Wagner & Hoegl, 2006). For this reason, organizational learning (Kuwada, 1998) taking place in collaborative relationships has widely been accepted as an antecedent of innovation taking place in these relationships (Fang et al., 2011; Hult et al., 2004, p. 44).

Building on the theory of organizational dynamic capabilities (Teece, 2007; Teece et al., 1997) and the relational view (Dyer & Singh, 1998), learning has been approached not only as an organizational phenomenon but also as an interorganizational phenomenon (Selnes & Sallis, 2003). The relational view considers interorganizational relationships an important avenue for creating innovation, renewal, and learning (Corsaro, Cantù, & Tunisini, 2012; Kale & Singh, 2007; Ritter, 1999). Particularly in relationships between customers and suppliers, relational learning enables both parties to identify ways to improve quality and efficiency as well as to reduce costs (Kale & Singh, 2009; Madhok & Tallman, 1998; Selnes & Sallis, 2003). Therefore, recent research in this field has considered learning a relational dynamic capability capable of benefiting all the parties involved in the R&D collaboration (Huikkola et al., 2013; Kale & Singh, 2009). That research has thus defined relational learning as "a relational dynamic capability that takes place at the level of R&D collaboration and is facilitated by such practices as relational investments, relational structures, and relational capital" (Heimeriks & Duysters, 2007).

The concept of relational joint learning presented in this chapter builds on organizational learning literature (Crossan, Lane, & White, 1999; Kuwada, 1998) that views that learning process as a dynamic capability (Huikkola et al., 2013; Kale & Singh, 2009). The theory of joint learning is built on the work of (Selnes & Sallis, 2003), who define joint learning as "a joint activity between the supplier and customer, where parties 1) share knowledge, 2) jointly make sense of it, and 3) integrate that knowledge into relational memory." The following sections introduce these three phases of the joint learning process. These phases are also summarized in Table 4.

2.3.1 Knowledge sharing

Knowledge sharing taking place in the relationship refers to the formal and informal transfer of knowledge between the parties (Chang & Gotcher, 2007; Selnes & Sallis, 2003). According to Tsai (2001, p.996), "knowledge transfer among organizational units provides opportunities for mutual learning and inter-unit cooperation that stimulate the creation of new knowledge and, at the same time, contribute to organizational units' ability to innovate." A remarkable amount of research on relational knowledge transfer regards knowledge accessibility as a major facilitator of innovation (Dyer & Hatch, 2006; J. L. Lin, Fang, Fang, & Tsai, 2009; Tsai, 2001). For this reason, R&D partnerships are often designed to encourage intended information and knowledge sharing between partners (Li, Eden, Hitt, Ireland, & Garrett, 2012, p. 1193). Accordingly, to facilitate the access to valuable knowledge resources that are available outside the firm boundaries, the organizations have to exchange information and share knowledge with their partners. In this transfer, different forms of interactions have been seen as important means of partners gaining, transferring, and absorbing new external knowledge (Corsaro et al., 2012, p. 780).

Knowledge and information transfer problems (i.e., information asymmetries) occurring in the relationship can significantly affect the governance costs of the relationship (Baldwin, 2007; Rindfleisch & Heide, 1997; Stump et al., 2002) and thus cause significant transaction costs. In a similar manner, any form of opportunistic behavior on the part of a partner has a negative impact on the information sharing and therefore on the joint learning in the relationship (Katila, Rosenberger, & Eisenhardt, 2008; Martinez-Noya, Garcia-Canal, & Guillen, 2013). For this reason, effective knowledge transfer and collective knowledge development in the relationship requires an open atmosphere (Garvin, 1993; Grönroos & Voima, 2013). The role of mutual trust, respect, and friendship are also essential facilitators of the creation of relational capital in the

relationship (Kale et al. 2000), which in turn enables close interaction and effective information sharing at the individual level between alliance partners (Inkpen & Tsang, 2005; Kale & Singh, 2007).

2.3.2 Joint sensemaking

Dialogue within the relationship involves the social process of interpreting and making sense of the shared information and joint development of knowledge (Daft & Weick, 1984; Selnes & Sallis, 2003). Accordingly, joint sensemaking aims to achieve a common understanding between parties (Weick et al., 2005). The parties build this understanding by finding a consensus by seeking to align their appropriate capabilities, knowledge, and expectations (Chang & Gotcher, 2007; Crossan et al., 1999; Huikkola et al., 2013; Kuwada, 1998). Different organizations vary in the ways they understand, make sense of, and utilize the same information, and hence there are differences in the mechanisms used to make sense of that information. For this reason, sometimes the information acquired in the relationship is rejected in the organization participating in the relationship; not because the information is unimportant to the organization, but because the organization lacks the ability to make sense of and absorb it (Selnes & Sallis, 2003). Previous research has shown that the ability of firms to absorb new knowledge that comes from outside the organization's own boundaries varies (Cohen & Levinthal, 1990; Stock, Greis, & Fischer, 2001; Zahra & George, 2002). Scholars have shown that those organizations with high absorptive capacity are more successful in terms of competitive advantage facilitated by innovation performance (Davis & Eisenhardt, 2011; Duysters & Lokshin, 2011; Dyer & Singh, 1998; Kale et al., 2000; Selnes & Sallis, 2003). Joint sensemaking is often challenging in the relational context, in which psychological, physical, and cultural distances between partners can be remarkable (Huikkola et al. 2013). This cognitive distance between parties can be reduced by using appropriate mechanisms and learning arenas, for example cross-functional and cross-organizational teams as well as frequent face-to-face interactions (Fang et al., 2011; Henneberg, Naudé, & Mouzas, 2010; Selnes & Sallis, 2003)

Particularly in the dynamic environments of knowledge-intensive technology organizations, understanding, employing, and integrating external knowledge is challenging because of its tacit and experimental nature, which makes it difficult to share, make sense of, or implement (Galunic & Rodan, 1998; Inkpen, 1996). In this context, finding appropriate learning arenas and practices is particularly important (Fang et al., 2011; Henneberg et al., 2010). Scholars have also shown that partners' adaptation to the partnership supports interaction and

sensemaking between partners (Brennan & Turnbull, 1999; Walter, 2003). In addition shared experience accumulated in any previous collaboration with the partner can improve and facilitate the collaboration and joint sensemaking in future projects (Nieto & Santamaría, 2007; Ragatz, Handfield, & Scannell, 1997; van Echtelt et al., 2008). Accordingly, experience ties the partners closer together and facilitates joint sensemaking.

2.3.3 Knowledge integration

In the process of joint learning, the partner organizations develop relationship-specific memories into which acquired and developed relationship-specific knowledge is integrated (Selnes & Sallis, 2003). This memory can be seen as a construct on both the individual and organizational levels (Walsh & Ungson, 1991). Individuals usually retain information and jointly-developed knowledge based on their own sensemaking, observations, and experiences, and store it in their memories. At the organizational level, shared memory is distributed in several places throughout the organization, and is aligned with organizational routines, traditions, and beliefs, as well as physical artifacts (Lukas, Hult, & Ferrell, 1996; Moorman & Miner, 1997; Walsh, 1995). Accordingly, organizational identity and managerial cognition (Walsh, 1995; Weick et al., 2005) play a central role as guides of the knowledge integration into relational memories on both the individual and organizational levels.

In the knowledge integration phase, the jointly developed relational knowledge is integrated into the relational structures in the partner organizations. Accordingly, this knowledge is seen as a relational resource spanning organizational boundaries and embedded within the interorganizational collaborative processes (Dyer & Singh, 1998). These interfirm knowledge resources might be related to new competences, skills, products, services, relational routines, structures, or working procedures (Cegarra-navarro, 2007; Johnson, Sohi, & Grewal, 2004; Lukas et al., 1996; Moorman & Miner, 1997). Accordingly, the phase of knowledge integration can be seen as the utilization and employment of the resources acquired and developed in the collaborative relationship. As the process of knowledge integration involves the transfer of shared and jointly-created knowledge into relation-specific resource or property, it might be regarded as knowledge implementation or institutionalization (Crossan et al., 1999; Fang et al., 2011; Kuwada, 1998). Knowledge institutionalization is the process of embedding learning into the organization undertaken by individuals and groups: a process that requires high absorptive capacity(Marsh & Stock, 2003; Stock et al., 2001) and an open organizational

culture (Weick et al., 2005). In the process of knowledge implementation, actions are specified and organizational mechanisms are put in place to ensure that actions are implemented in the organization (Crossan et al., 1999, p. 525). Accordingly, the partners utilize the jointly-created knowledge by implementing it into new technologies, services, or processes, for instance (Williams & McGuire, 2008). In R&D organizations, the outcomes of the joint knowledge creation are typically implemented into prototypes to be tested and evaluated, and then commercialized as final products (Chen, Damanpour, & Reilly, 2010).

Table 4. A summary of the three phases of joint learning.

	Knowledge sharing	**Joint sensemaking**	**Integration of the knowledge**
Central goal	Formal and informal transfer of knowledge between the parties	Achieving common understanding among parties by interpreting and making sense of the shared information Joint development of knowledge	Knowledge-based resources acquired and developed in the relationships are embedded as interfirm resources
Facilitators	Mutual trust, respect, and friendship Embeddedness Information sharing practices and frequent interactions	Cross-functional and cross-organizational teams Partnership-specific adaptations Shared experience accumulated in previous collaboration	High absorptive capacity Ability and willingness to progress knowledge implementation
Barriers	Information asymmetries Threat of partner's opportunistic behavior	Physical, psychological, and cultural distances between actors	Managerial attitudes and strong organizational identity

2.4 Implications of learning and boundaries in R&D

As collaboration in R&D relationships is a significant facilitator of innovation performance and competitiveness for high-technology companies (Nieto & Santamaría, 2007; Un et al., 2010), technology firms today tend to regard learning and access to new, valuable knowledge as one of the most important reasons to use alliances with external partners (Kale et al., 2000). In learning

alliance structures, the partners strive to learn or internalize critical information, know-how, or capabilities from each other (Kale et al., 2000; Khanna et al., 1998). That process helps the partner firms to acquire knowledge or learn some critical information from the other side of the relationship. In this section, the impact of joint learning and learning alliances is considered from the viewpoint of the four organizational boundary conceptions presented earlier in this section. The key conclusions of this discussion are summarized in Table 5.

2.4.1 Joint knowledge creation as resource development

When considering the four organizational boundary conceptions presented in this dissertation, it is obvious that the competence conception and its underlying resource-based view play a central role in the organizational learning issues. This is because according to the RBV, partnerships are a means to increase and complement a firm's own internal competences (Parmigiani & Mitchell, 2009), and firms use external relationships and relational learning to gain access to new knowledge, resources, and competences, which in turn allow them to aggregate, collect, and absorb valuable, heterogeneous, and unique knowledge from their partners (Cegarra-navarro, 2007; Fang et al., 2011; Khanna et al., 1998). As learning alliance linkages are seen as key channels for knowledge sharing and transfer between firms (Ahuja, 2000; Li et al., 2012), joint learning taking place between alliance partners facilitates the knowledge transfer, the joint process of new knowledge creation, and knowledge utilization and implementation between partners (Kale et al., 2000; Selnes & Sallis, 2003). Therefore, by complementing its internal knowledge resources and competences with those available in learning alliances, a firm is able to gain competitive advantage and improve its innovative performance (Parmigiani & Mitchell, 2009). Accordingly, according to the RBV, and the competence view, firms benefit from their learning alliances by obtaining access and internalizing knowledge-based resources from them (Kale et al., 2000; Khanna et al., 1998).

2.4.2 The learning race and R&D efficiency

R&D executives managing learning alliances in firms increasingly face challenges around how to maximize the access to external competences and knowledge resources provided through the relationship and simultaneously protect their own, valuable knowledge resources that can have strategic meaning in terms of competitive advantage (Kale et al., 2000; Li et al., 2012). Building on the transaction cost theory (TCA) that emphasizes the relevance of partner

opportunism in interorganizational relationships, the literature on learning alliances calls this a *learning race* (Faems et al., 2005; Khanna et al., 1998), in which the partners can engage in opportunistic attempts to outlearn each other. This kind of "race" can cause significant tensions in the interfirm relationships, because the alliance structures can help the firms learn and absorb new and valuable knowledge or capabilities in the relationship, but at the same time, the partners can also expose their valuable technological assets to opportunism hazards, and hence increase the risk of losing the firm's critical capabilities to the alliance partner (Kale et al., 2000), or third parties such as competitors through knowledge leakages (Hoecht & Trott, 2006; Li et al., 2012; Oxley & Sampson, 2004). This means that the firms face the challenge of managing the balance between "trying to learn and trying to protect" (Kale et al., 2000, p. 217). As the efficiency conception and TCA perspectives suggest, protection from the partner's opportunistic behavior increases the cost of relationship governance (Dyer, 1996) in terms of control and safeguarding (Hoecht & Trott, 2006; Rindfleisch & Heide, 1997). For this reason, firms should favor an internal, hierarchical governance model in those relational activities that might expose it to market opportunism (Argyres & Zenger, 2012). They should also be wary of participating in any learning alliance that might bring a risk of losing their valuable assets or knowledge to alliance partners (Kale et al., 2000).

However, in contrast to the transaction cost approach, the literature on alliances indicates that close personal relationships, trust, and respect in relationships between firms can help the alliance partners to successfully balance the acquisition of new capabilities and simultaneously minimize the risk of opportunistic behavior in the relationship (Coulter & Coulter, 2003; Kale & Singh, 2009; Kale et al., 2000). According to (Gulati & Sytch, 2008, p. 166), "higher levels of trust are related to reduced negotiation costs, lower levels of conflict, superior information sharing, and account for high levels of cooperation and organizational performance." These are factors that significantly impact on the transaction costs of the relationship (Dyer & Chu, 2003; Zaheer et al., 1998). Moreover, as described earlier, partners in close trusting relationships learn to collaborate effectively by adapting to each other's processes and working procedures (Kale & Singh, 2007; Zollo & Winter, 2002). Each partner can also develop alliance capabilities that facilitate the acquisition of alliance management expertise (Kale & Singh, 2007, p. 984). Moreover, those learning alliances with close relationships between firms build mutual trust (Lewicki et al., 2006), which is in turn likely to reduce the transaction costs related to governance, control, and safeguarding (Dyer & Chu, 2003; Zaheer et al., 1998).

2.4.3 Joint learning, resource dependency, and mutual trust

When partner firms in the learning alliance share knowledge with each other and interact closely to create new knowledge, it is obvious that the firms become dependent on each other. This is because the shared and jointly developed knowledge is relationship specific, not firm-specific, property stored in the relationship-specific memory structures to which both partners have access (Fang et al., 2011; Selnes & Sallis, 2003). The extent of mutual dependence depends on the nature of the relationship-specific knowledge and how critical it is for each partner in the relationship. If the knowledge is equally important for both parties, then there is dependence symmetry in the relationship and the partners are mutually dependent (Gulati & Sytch, 2007; Roseira et al., 2010). As discussed earlier, this kind of dependence symmetry can prompt the formation of more embedded ties between partners and also the emergence of mutual trust (Gulati & Sytch, 2007, 2008), which in turn facilitates more efficient and close collaboration in the future (Verona, 1999). However, if there is dependence asymmetry in the relationship (i.e., one partner is more dependent on its partner than vice versa), the learning relationship can fuel one partner's power (Gulati & Sytch, 2007, p. 35).

In the R&D networks of knowledge-intensive technology arenas, it is usual that there are instances of dependence in the relationships between firms, and such dependence is often due to the specialized competences and capabilities developed in the learning alliances (Davis & Eisenhardt, 2011). However, as discussed in the previous section, trust becomes important in situations characterized by risk and uncertainty (Gulati & Sytch, 2008; Zaheer et al., 1998), and in long-term learning alliances the partners can typically learn to build relational capital and mutual trust at the personal level through close personal relationships (Kale & Singh, 2007; Kale et al., 2000). This interpersonal trust can develop to become an interorganizational phenomenon if organizational members collectively trust a partner firm (Zaheer et al., 1998, p. 143). Such trust is often a result of the partners' confidence in each other's trustworthiness facilitated by familiarity and friendship developed in prior interaction between the firms (Gulati & Sytch, 2008). Accordingly, the firms actually learn to trust each other in their long-term collaboration (Kale et al., 2000). As such, this kind of interorganizational trust occurring between collective entities represents an organization's expectation that another firm does not act opportunistically when dealing with that organization (Gulati, 1995; Gulati & Sytch, 2008, p. 167). This, in turn enables firms to develop joint learning practices and also together find ways to utilize the jointly developed knowledge in such a manner that both parties can utilize it without fear of one partner's opportunistic behavior (Kale et

al., 2000; Lewicki et al., 2006). Organizational trust can also have a significant impact on the firm boundaries, since trustworthiness can demonstrate a firm's willingness to favor a particular partner over other firms in cooperative agreements, and also spur using looser contracts to structure those agreements (Gulati, 1995; Gulati & Sytch, 2008, p. 167).

2.4.4 Learning as organizational identity

As discussed earlier, a manager's personal views and organizational traditions can dominate the boundary considerations (A. D. Brown & Starkey, 2000; Tripsas, 2009), especially in stable environments where external circumstances do not force managers to change the status quo created by sensemaking (Santos & Eisenhardt, 2005). In these kinds of circumstances, a strong organizational identity is likely to increase resistance to any new knowledge available outside the organization (Galunic & Rodan, 1998, p. 1200). Accordingly, managerial attitudes and organizational traditions have a certain impact on the external relationship that can enable learning process between partners. However, particularly in environments marked by rapid change and technological development, the aspect of learning cannot be ignored in the managerial sensemaking without a significant negative impact on competitive performance (Burgelman, 2002; Rindova & Kotha, 2001; Teece et al., 1997). Accordingly, in organizations operating in dynamic environments, learning is often embedded in the organizational identity (A. D. Brown & Starkey, 2000; Galunic & Rodan, 1998), and managerial sensemaking appreciates learning as a necessary organizational process (Kogut & Zander, 1996).

The concept of the learning organization sees firms as organizations that represent the social knowledge of coordination and learning (Kogut & Zander, 1996). (Garvin, 1993, p. 80) defines a learning organization as "an organization skilled at creating, acquiring, and transferring knowledge, and at modifying its behavior to reflect new knowledge and insights." Accordingly, an organization with a learning oriented identity actively seeks external opportunities for learning (Kuwada, 1998; Paananen, 2012). The organizational identity with a strong learning orientation is often a crucial dynamic capability for firms operating in areas marked by strong competition and rapid environmental changes. Accordingly, for those learning organizations operating in these environments, joint learning taking place in external partnerships can also change the organizational identity by providing their managers with new information and templates for novel ways of operating (Burgelman, 2002; Galunic & Rodan,

1998). This, in turn, has a certain impact on the boundary considerations (Santos & Eisenhardt, 2005).

Table 5. A summary of the relationships between boundary theories and learning.

	Factors favoring relational joint learning and participation in learning alliances	**Factors prejudicing relational joint learning and participation of learning alliances**
Efficiency (TCA)	In close learning relationships, the parties typically develop alliance capabilities and mutual trust, which in turn are likely to reduce transaction costs related to governance, control, and safeguarding.	In learning alliances, the firms can expose their valuable technological assets to their partner's opportunism, and thus risk losing their critical capabilities to the alliance partner or other third party. This increases the control and safeguarding costs of the relationship.
Competence (RBV)	Joint learning is seen as a means of accessing and internalizing valuable and heterogeneous knowledge available on market.	-
Power (resource dependency)	Valuable knowledge resources gained in joint the learning process can improve the firm's competitiveness and relative power in the partner network.	If there is dependence asymmetry in the relationship, the learning relationship can become a source of the partner's power.
Organizational identity	Organizations with a learning identity are able to utilize the learning process taking place in the external relationships and thus improve their competitiveness.	A strong organizational identity is likely to increase resistance to any new knowledge available outside the organization, especially in stable environments.

3. METHODOLOGY

This chapter discusses the research methodology applied in this dissertation. It begins by describing the philosophical paradigms of the dissertation and then explains the research design and the methods used.

3.1 Scientific premises

The theories of organization are based on the philosophy of science (Burrell & Morgan, 1979). This means that whenever research is conducted on an organization, a researcher must make assumptions on the nature of the surrounding world. In scientific literature, this process is referred to as ontology (Burrell & Morgan, 1979; Easton, 2002) and its assumptions concern the essence of a studied phenomenon and refer to questions of reality without an individual being conscious of it. Epistemology, on the other hand, refers to the nature of knowledge (Burrell & Morgan, 1979), and its assumptions concern the grounds of the knowledge, and refer to questions such as how knowledge is acquired and the truth discovered. The theoretical framework for philosophical paradigms originally presented by (Burrell & Morgan, 1979, p. 22) is widely accepted in social sciences. In their 2x2 framework, Burrell and Morgan (1979) present different paradigms on a subjective–objective continuum concerning the assumptions of the nature of science as well as a regulation–radical change dimension concerning assumptions on the nature of society. The resulting four paradigms are: radical humanist, radical structuralist, interpretative, and functionalist. The subjective paradigms on the left-hand side see the world as a product of one's mind, in terms of individual cognition. The objective paradigms on the right-hand side view the world objectively and see reality as given.

Management studies are usually positioned in the lower part of the matrix, since regulation reflects the nature of society and the environment better than radical change. The functionalist paradigm is applicable in studies assuming that the world consists of structures, processes or relationships that can be understood by quantitative hypothesis testing (Örtenblad, 2002). On the other hand, the case studies of a qualitative nature might better fit the interpretative paradigm that considers the subjective phenomena of individuals and their cognition in organizations (Easton, 2010). Therefore, the case study approach used in the articles within this dissertation is best fitted to the interpretative paradigm. However, as the case-based articles use methods that aim at increase objectivity, and a proportion of the results are also validated in terms of quantitative

analysis, this dissertation actually combines elements from both the interpretative and functionalist paradigms. This kind of approach is in line with the findings of (Kakkuri-Knuuttila, Lukka, & Kuorikoski, 2008) who suggest that interpretative studies in business can contain both subjective and objective elements.

This dissertation follows the philosophical theory of pragmatism. Pragmatism emphasizes the practical role and value of knowledge and therefore does not see truth as an absolute concept but as a form of knowledge useful to people researching in the field, but which is also open to criticism and renewal (Easton, 2010). Accordingly, pragmatists view science as aiming to achieve the best available explanation of the issue raised (van Aken, 2009; Peirce, 2001). Pragmatists argue that creating knowledge, information, and beliefs is a process that is always influenced by researchers prior assumptions and understanding of their topic (Peirce, 2001). This pre-understanding is often embedded in the original motivation to start the research and formulate the research question. According to one of the most well-known pragmatists, John Dewey, research is always an attempt to solve a problematic situation emerging from action (Dewey, 2003). Regarding the topic of this dissertation, the author had practical previous experience and understanding of R&D collaboration in industry, which encouraged him to find answers to the research gaps defined in this dissertation. This inevitably influenced the choice of research topic, research questions, and the empirical choices during the research process. This kind of approach is in line with Dewey's pragmatic research paradigm of achieving and creating new knowledge in practical contexts, "learning by doing" (Dewey, 2003).

Scientific reasoning has three forms that can be applied to draw conclusions based on empirical results, deductive, inductive, and abductive. In inductive reasoning, the research process starts from a phenomenon that is empirically tested, and theory is built on the findings based on the empirical evidence. Deduction, in contrast, is strictly built on existing theory, and it formulates testable hypotheses based on it. Both of these reasoning approaches cause issues in the practical research process, at least in their purest form. This is because pure induction actually prevents the researcher from using earlier research as basis of the current research. Pure deduction, on the other hand, actually prevents researchers from extending earlier theories with their empirical findings (Perry, 2005). Interpretive and case studies often use abductive reasoning (Easton, 2010) in their analysis and conclusions. In abduction-based reasoning, the research process utilizes the continuous interplay between theory and empirical data to achieve the best possible explanation of the issue (Dubois & Gadde, 2002; Peirce, 2001). This process is also referred as systematic combining

(Dubois & Gadde, 2002). The abductive reasoning form is applied in Articles of 1 and 2 of this dissertation. The interplay and discussion between the underlying theories and collected interview data is the major reasoning strategy in these studies. In Article 3, its quantitative research approach dictates that the reasoning is closest to the deduction form.

3.2 Research design

The research design brings together the tasks, decisions, and choices on the research process. The empirical phenomenon studied in the research process influences and guides the whole process, the choices of methodology, and the underlying assumptions. This section explains the rationale driving the choices related to the research design and methodology used in this dissertation.

This dissertation analyses the practices and mechanisms by which individual actors in R&D organizations—and also in organizations formed by these actors—behave in collaborative interorganizational relationships. As described in the introduction, this research aims to improve understanding on the relational-level phenomena, mechanisms, and practices related to organizational boundary setting and joint learning in R&D relationships. Accordingly, the design of this research is based on four directly related research articles focusing on organizational boundaries and joint learning in knowledge-intensive R&D collaboration. Articles 1, 2, and 4 are based on multiple case study approach whereas Article 3 is a survey article. In this sense, this dissertation represents mixed method approach. However, whereas the most important scientific contributions of the dissertation are coming from the multiple case studies, and the main purpose of Article 3 is to validate some key conclusions of Article 1, the main methodological avenue of this dissertation is multiple case study approach. The target industry for this study is the Finnish high-technology industry. With its knowledge-intensive and innovative nature, the high-technology industry (Thornhill, 2006; Yasuda, 2005) provides an optimal platform for a researcher to identify relationships and underlying mechanisms related to the utilization of external partnerships as sources of new knowledge (Knudsen, 2007; Sobrero & Roberts, 2002) and the building of dynamic capabilities (Davis & Eisenhardt, 2011; Huikkola et al., 2013; Un et al., 2010). This is because the knowledge accessibility, knowledge creation abilities as well as competence considerations are the essential success factors in this rapidly changing field of industry (Kapoor & Adner, 2012; Macher, 2006).

3.2.1 Case study as research method

Case study methods (Eisenhardt, 1989) have been found to be particularly useful when studying complex and evolving relational phenomena in industrial markets (Beverland & Lindgreen, 2010; Easton, 2010). These relational-level phenomena include personal interactions, decision processes, and decision procedures and outcomes in complex real-life contexts (Woodside & Baxter, 2013). The case study method is a suitable approach for examining partnering, purchasing, and supply chain management mechanisms, particularly in view of the complexity of evolving relationships and network interactions (Beverland & Lindgreen, 2010; Dubois & Araujo, 2007). (Easton, 2010) defines case study research as: "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." Based on another, broader definition, case study research is "an inquiry that focuses on describing, understanding, predicting, and/or controlling the individual (i.e., process, animal, person, household, organization, group, industry, culture, or nationality)" (Woodside & Baxter, 2013, p. 383). Accordingly, case study research with multiple cases is a research method that investigates a small number of social entities or situations about which data is collected using multiple information sources through an iterative research process (Easton, 2010, p. 119). A case-based research design usually focuses on the definition of the sample, research questions of the study, unit of analysis, methods for data collection and the criteria of evaluating the validity of the findings of the study (Easton, 2010; Woodside & Baxter, 2013).

3.2.2 Definition of the sample

In case research, a case is a single instance, a sample of one (Easton, 2010). Although the sample size in case study research is never large enough to qualify for the use of statistical inference, literature on case-based research does not provide an optimal number for the cases used (Easton, 2010). For example, in her widely cited paper Eisenhardt (1989) offers the following advice regarding the number of cases to be used: "Finally, while there is no ideal number of cases, a number between 4 and 10 cases will usually work out well" (Eisenhardt, 1989). In each of the case-based articles of this dissertation, the number of cases is six. According to (Yin, 2009), multiple sources of evidence should be used in qualitative data collection. Therefore, the case data collected includes interviews, and secondary data, such as corporate brochures and archives, internet information, and descriptions of the partnership. The cases for the studies were selected purposively, rather than randomly, drawing on the concept of the

information-rich case studies (Patton, 1990). According to (Patton 1990, p.169): "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." Accordingly, to select cases, and recruit interviewees for the semi-structured case interviews, the researchers used different network platforms and contacts to identify cases of long-term and close collaborative R&D supplier–customer relationships.

3.2.3 Research questions and unit of analysis

In the case-based research, the research questions are usually definable in terms of the questions that are explanatory in nature: *why* and *how*. (Easton, 2010; Yin, 2009). The research question of this dissertation was formulated to find explanations on the questions regarding the relational practices and mechanisms behind coevolving boundary formation and learning in R&D relationships. Accordingly, the question, and its sub-questions presented in the introduction section are *how* questions: questions particularly well suited to case studies concerning relationships with complex set of factors (Easton, 2010).

As case studies are often based on multiple information sources and perspectives behind them, the focus of the research can be ambiguous (Easton, 2010; Yin, 2009). Explicitly defining the unit of analysis of the study helps in understanding the research contribution in contrast to other studies in the same field. As the main theories of this dissertation, organizational boundaries, relational joint learning, and R&D collaboration are all relational-level phenomena between networked business actors, it is natural that the unit of analysis in all the articles related to this dissertation lies in the relationships between collaborative firms.

3.2.5 Data collection

In-depth data collection in case-based research typically involves multiple sources of information-rich data (Beverland & Lindgreen, 2010) such as people, documents, databases, printed materials, and similar. However, in the relational contexts the main data collection approaches include on-site interviews and face-to-face observations (Woodside & Baxter, 2013). The case data collected for the articles 1,2, and 4 of this dissertation took place in 2013–2015. The process started with several face-to-face meetings and discussions with the focal organization's R&D executives. The purpose of these first meetings was to obtain general information on the organization's R&D activities and strategies for supplier involvement. At the same time, the researchers conducted a literature

survey and collected secondary data including company data, brochures, reports, financial data, and other printed material. The case data collection was carried out through using four interview rounds. In the first round, the researchers were aiming to improve understanding of the rationale behind the organization of R&D work into internal tasks or external work allocated to suppliers. At the same time, the researchers developed the first version of a semi-structured questionnaire related to boundary theories and learning. The interviewees in the first round were the focal organization's R&D executives and also managers responsible for the product portfolio and for research. During the second interview round, the researchers conducted a pilot study to extend their understanding of the topic, the phenomenon studied, and also to validate their data collection and analysis methods (Beverland & Lindgreen, 2010; Yin, 2009). A pilot study was used to test the researchers' preliminary, semi-structured interview template (Eisenhardt, 1989). That was done in group interviews of the customer organization's R&D executives and with executives of one, selected supplier company. The data collected in the pilot study helped generate a final template used in the case interviews of the third interview round. The case interviews were conducted as group interviews for the representatives of both sides of each case relationship, aligning with the call of (Brennan & Turnbull, 1999) to involve interviewees from both sides of the relationship to validate the analysis. Using the group interview method also encourages the interviewees to discuss the interview questions with each other and arrive at a common answer. The interviewees were selected based on their experience and responsibility for the relationship, and they were key decision makers in the relationship. On the final interview round, the preliminary results of the case interviews as well as researchers' interpretations were discussed with the representatives of the focal organization. This interview round provided an opportunity for both researchers and company representatives to pose additional questions, present new viewpoints, and comment on the outcomes of the research.

As mentioned earlier, Article 3 uses a quantitative research approach to validate one of the key conclusions drawn in the qualitative case research presented in Article 1. The study collected data from R&D supplier-customer relationships in Finland in 2015 by using an internet hosted questionnaire. Before distributing the questionnaire, research staff contacted selected companies by telephone to identify and encourage the most relevant respondents to participate the survey. The final dataset comprised 169 R&D relationships indicating response rate of 50,6%.

3.2.6 Reliability and validity

To ensure the reliability and validity of the case-based research, a data triangulation approach was used (Beverland & Lindgreen, 2010; Huberman & Miles, 1994). The literature presents four perspectives on triangulation, those of theory, data, methodology, and the investigator. Concerning theory, the data collected was analyzed from the viewpoint of organizational boundary and relational learning theories. Data triangulation involves the collection of data from various sources. In the data collection presented in the articles, additional data was harvested from firms' websites, annual reports, and other written sources both before and after interviewing the supplier and customer in each relationship. In addition, interview responses obtained from both sides of each supplier–customer relationship were compared as suggested by (Brennan & Turnbull, 1999). Finally, investigator triangulation is used to control the bias caused by single researchers in data analysis. In Articles 1, 2, and 3, two researchers were involved in the analysis tasks, and the results were also discussed with the industrial partner. In Article 4, which is practical in nature, the research work, and analysis was conducted in close collaboration with staff from the industrial partner.

In the methodology of triangulation, qualitative, and quantitative methods might be combined. In this dissertation, Article 3 presents a quantitative method to validate one of the key conclusions drawn in the qualitative case research presented in Article 1—the positive relationship between competence and efficiency, and the mediating impact of relational joint learning on that relationship. This research model was tested in Article 3 by performing an ordinary least squares regression analysis for measures of resources, efficiency, and learning adopted from previous literature. The mediating impact of joint learning was indicated based on the criteria originally presented by (Baron & Kenny, 1986).

4 RESULTS AND DISCUSSION

This chapter presents the results and the discussion of the overall contributions based on the results of the four constituent articles of this dissertation. In addition, practical implications, limitations, and suggestions for future research are discussed.

4.1 Summary of results

The results of this dissertation are presented in its Articles. The purpose of this section is to briefly summarize the results of the articles, present their individual contribution to this dissertation and to highlight the objective and viewpoint of each article.

4.1.1 Boundary formation in R&D relationships

Article 1 uses qualitative interview data collected from six supplier–customer relationships in Finland to investigate the boundary formation in R&D collaboration. The underlying theory in the article is based on four conceptions of organizational boundaries, efficiency, competence, power, and identity. The interview data revealed a rich set of relational practices that were able to explain the boundary formation between technology organizations and their R&D suppliers, all related to the theories behind the boundary conceptions as summarized in Figure 6. The results also revealed interesting interdependencies between boundary formation mechanisms. Competence in the R&D relationship, for instance, facilitates relational efficiency, introduces dependency (power) and facilitates the formation of organizational identity in the relationship. In a similar manner, increased power in the relationship tends to increase efficiency whereas it can also force the partner firm to re-consider its identity. Consequently, the focused identities of partners are able to facilitate more efficient collaboration. All the mechanisms related to interdependencies and interaction between boundary explanations were found to be facilitated by the mechanisms of mutual trust and joint learning in the collaborative relationship. This is because relational capital facilitated by mutual trust is a necessary condition for adaptation and embeddedness in the relationship, which in turn facilitate the partners' commitment to long-term collaboration. Mutual trust plays a particularly important role in the interaction between power- and competence-

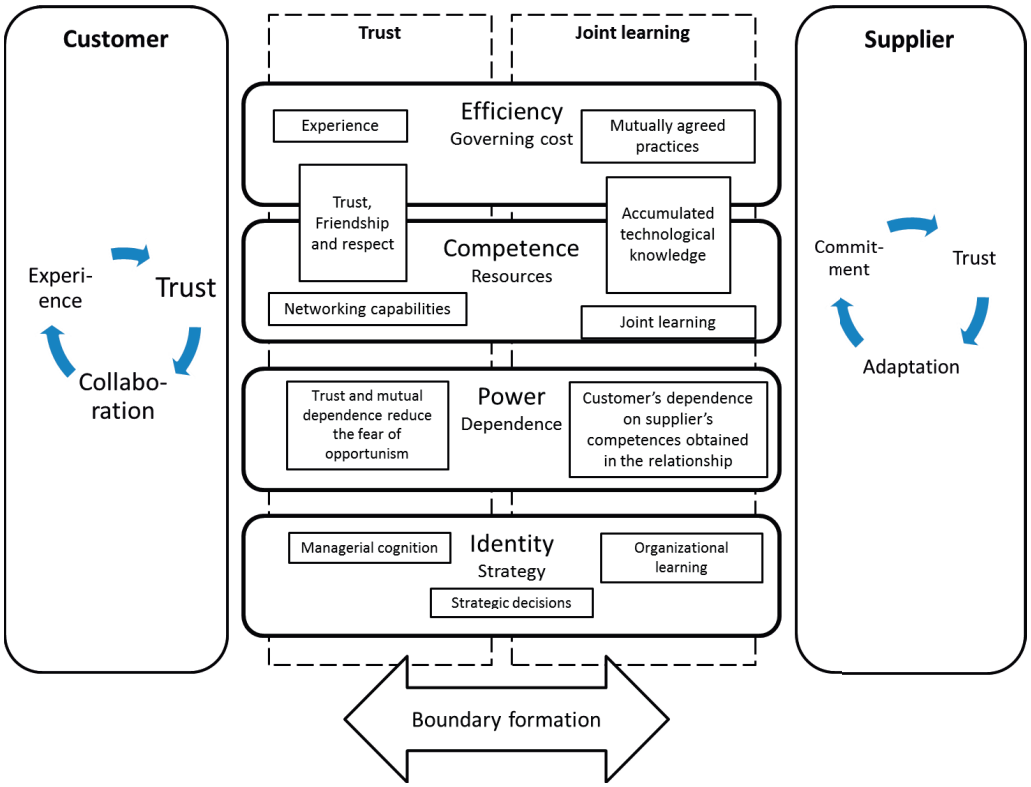

Figure 6. Factors affecting boundary formation in long-term R&D collaboration between customer and suppliers.

based boundary formation, since in the relationships with high levels of trust, the one party often tolerates a considerable degree of dependence on the partner's competences, and thus continues the collaboration despite the power asymmetry in the relationship. Relational joint learning, on the other hand, is the basis of the joint creation of partnership-specific knowledge-based resources, and therefore a necessary process behind competence-based boundary formation. However, the knowledge resources developed in the joint learning process tend to introduce dependence in the relationship, and at the same time learning also has a positive effect on the relational efficiency.

4.1.2 Learning in internal and external R&D collaboration

Article 2 examines R&D collaboration from the viewpoint of joint learning. Building on the three phases of the joint learning process, knowledge sharing, joint sensemaking, and knowledge integration, the study investigates the relational practices and mechanisms facilitating learning and joint knowledge creation in R&D relations. Of the six cases examined, three were relationships with external R&D suppliers and three reflected relationships with a company's

internal globally dispersed R&D subsidiaries. The study was therefore able to compare the relational learning practices occurring in the external and internal R&D collaboration. The results summarized in Figure 7 reveal that the facilitators of joint learning in internal and external R&D collaboration are interrelated in terms of a linked process consisting of dependence, embeddedness, and innovation. In addition, according to the study, mutual dependence caused by knowledge, competences, and accumulated experience gained in the relationship facilitates embeddedness between partners. Embeddedness and close personal-level relationships between partners, in turn, predict innovative outcomes for the relationship. As presented in Figure 7, joint learning in internal R&D collaboration is facilitated by motivational factors, whereas in external relationships the role of trust is emphasized. The reason for this difference is that external relationships are managed based on the logic of market governance, whereas internal relationships are based on hierarchical governance. This, in turn, makes separate coordination mechanisms essential.

4.1.3 Relationship between resources and efficiency

Article 3 is a quantitative study that aims to verify the positive relationship between the resources obtained in external R&D collaboration and the governance efficiency of the supplier relationship. It also suggests that joint learning between R&D alliance partners has a positive mediating effect on this relationship. The study collected quantitative survey data from 169 supplier–customer relationships in the R&D area in Finland. The measures for resources, efficiency, and joint learning were designed based on previous literature, and their relationships were tested by performing ordinary least squares regression analysis. The mediating impact of joint learning was tested by using the approach based on three conditions originally suggested by (Baron & Kenny, 1986). The results revealed that the resources have a significant and positive effect on governance efficiency and joint learning fully mediates this effect.

4.1.4 Managerial tool supporting R&D outsourcing decisions

Article 4 responds to one central outcome of Article 1 suggesting that managers should consider a wide range of factors to facilitate rational and systematic decision making when evaluating R&D outsourcing and insourcing activities. It presents a tool for managerial decision making that is based on four organizational boundary theories: competence, efficiency, dependence, and identity. The tool was designed primarily to serve two purposes in managerial decision making. The first is to help managers decide whether a particular R&D

task is suitable to outsource to an external supplier and the second is to help managers to decide which of the known supplier candidates is best suited to perform the task. The tool was developed as a part of a qualitative multiple case study on R&D supplier–customer relationships and was empirically tested with real decision cases in an R&D organization.

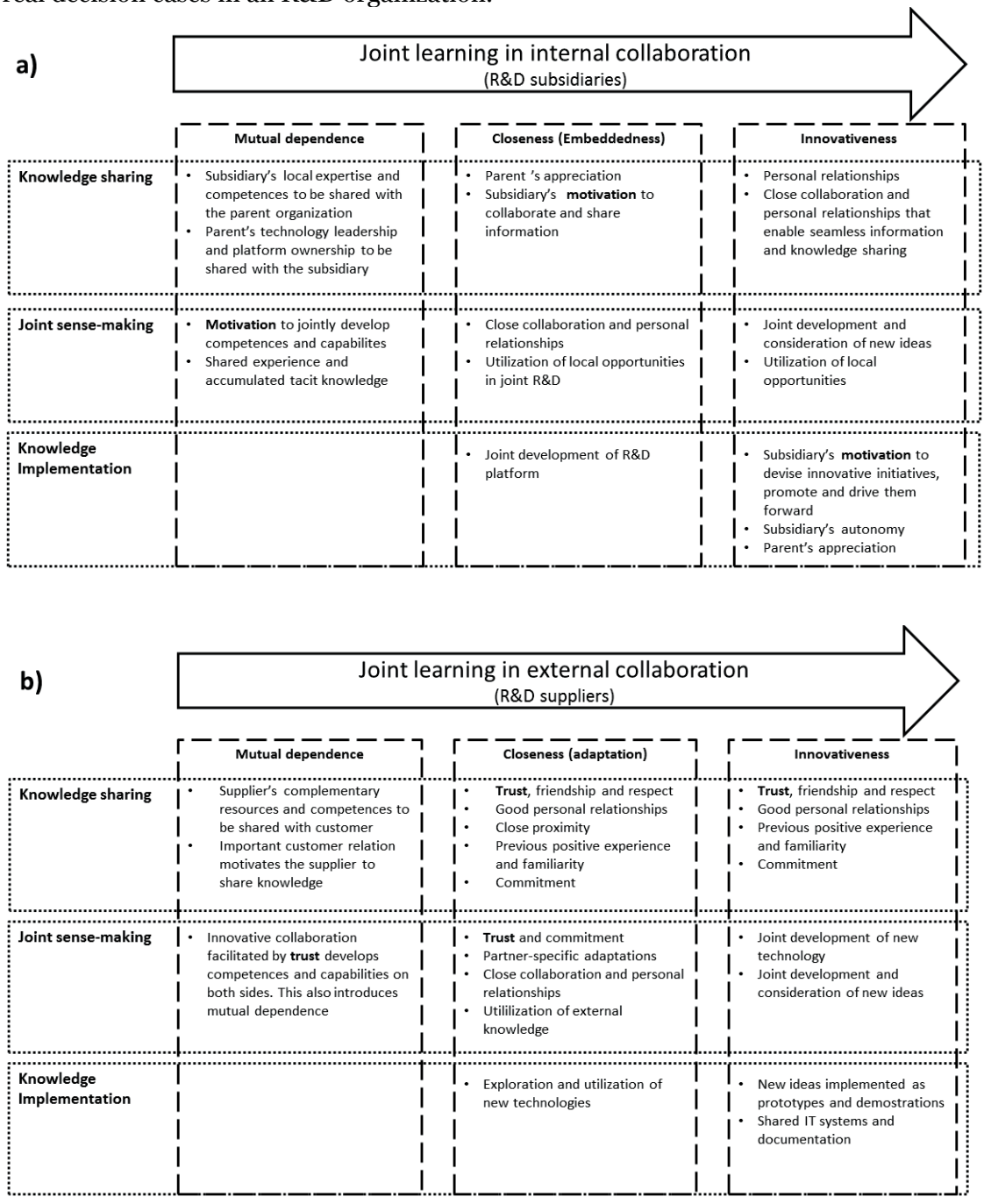

Figure 7. The facilitators of joint learning in the R&D network containing a) internal and b) external relations.

4.2 Theoretical contribution

The aim of this dissertation is to improve understanding on the formation of organizational boundaries and relational joint learning in the context of R&D collaboration by answering the following research question: *How do organizational boundary explanations interplay and coevolve in long-term collaboration partnerships and how does relational joint learning facilitate this development?* This question is approached from different viewpoints in four articles, each of which make individual contributions and have their own research questions.

The first article aims to answer the question: *Which practices are related to firm boundary conceptions, and how do they interplay in long-term R&D relationships?* This research question is motivated by the lack of previous research on the interrelation and interplay between different boundary explanations in the context of R&D collaboration, and also by the need to understand the practical mechanisms affecting the boundary formation between technology organizations and their R&D suppliers. Using a qualitative comparative multiple case study approach, this article examines a network of R&D relationships and extends the R&D collaboration literature by analyzing long-term collaborative supplier–customer relationships in terms of four organizational boundary theories. As the first contribution, the results reveal that it is possible to identify a number of mechanisms and practices that explain boundary formation between a technology organization and its supplier network. In particular, the article establishes that an organizational identity based on managers' personal, identity-based views, and experiences tends to dominate other, more rational boundary considerations. As the second contribution, the results also suggest that organizational boundary theories are interconnected via mutual trust developed in long-term collaboration as well as relational joint learning, which both facilitate effective, and innovative knowledge creation and utilization in long-term partnerships. Accordingly, the study suggests that competences developed within the relationship actually improve the transactional efficiency, as the partners in a joint action learn to collaborate effectively.

The second article concentrates on the joint knowledge development in R&D relationships facilitated by a process of joint learning (Selnes & Sallis, 2003). Joint learning is a process of particular importance for interorganizational R&D collaboration because it involves the exchange and joint development of tacit experimental knowledge that is difficult to transfer or utilize outside the relationship (Chang & Gotcher, 2007; Huikkola et al., 2013), and because it has a

clear positive effect on the partners' innovativeness (Duysters & Lokshin, 2011; Li et al., 2012). Accordingly, Article 2 seeks to answer the question: *Which factors in R&D collaboration practices facilitate innovative joint learning in an R&D network featuring internal and external relationships?* This research question was motivated by the observation that the facilitating relational mechanisms behind joint learning are a topic neglected in the previous literature, especially when internal and external R&D relationships are considered. Another motivator for this question was the finding from Article 1 about the facilitating role of joint learning as an explanation for the boundary formation between organizations. Article 2 makes three major contributions. First, it extends the existing literature on relational learning in the R&D context by highlighting the linked roles of mutual dependence, embeddedness, and innovativeness in the relational joint learning process. Second, the article makes a contribution to the existing theory of relational joint learning through its findings on the key roles of motivation and trust as facilitators of efficient R&D collaboration in the context of internal and external relationships respectively. Third, the article extends the literature on R&D collaboration by presenting factors and mechanisms facilitating the coordinating internal and external R&D relationships.

Article 3 is a quantitative research piece that seeks to improve understanding of the relationship between the resources and knowledge acquired in the collaborative R&D relationship and the governance efficiency of these relationships by answering the question: *What is the impact of resources provided by the R&D supplier relationship on the efficiency of the relationship, and how does joint learning taking place in the relationship facilitate this impact?* Accordingly, the article aims to investigate the interactions between the two most common boundary theories, the RBV and TCA and thus to narrow the research gap indicated in the previous literature (Argyres & Zenger, 2012; Santos & Eisenhardt, 2005). The article also seeks to validate the observation of the positive relationship between the resources and knowledge acquired in interorganizational R&D collaboration and the governing efficiency of the R&D supplier relationship presented in Article 1. Article 3 therefore contributes to the existing R&D collaboration literature in three ways. First, it shows that there is a positive association between the resources provided by the collaborative relationship and transactional efficiency collaborative relationships. This observation is important for knowledge-intensive high-technology relationships, in which valuable external resources can complement internal competences and improve performance. Second, Article 3 addresses the calls presented in literature to extend the understanding of the interactions and joint impact between the RBV and TCA theories explaining firm boundary formation (Santos & Eisenhardt 2005, p.503). Third, Article 3 shows how joint learning between

R&D partners mediates the link between resources and governance efficiency in their relationships.

Article 4 presents a managerial outcome of the findings of Article 1, in which one of the key conclusions was that decisions concerning the organization of R&D work into internal and external tasks in technology organizations are often dominated by identity-based managerial sensemaking rather than rational reasoning, and therefore Article 1 suggests using objective analysis methods that could question accepted decision making practices and conventions. To serve this end, a managerial decision making tool was designed. This practical tool uses the organizational boundary theories presented in Article 1 as a theoretical framework. Accordingly, the main contribution of Article 4 is to introduce a tool capable of facilitating the decision making related to R&D outsourcing and partner selection. It provides a practical but theoretically grounded way to rapidly evaluate and compare internal R&D capabilities with those available externally, and thus assist the R&D managers responsible for outsourcing to make rational decisions.

In addition to the theoretical implications of the individual articles, this dissertation as a whole provides insights into the R&D collaboration literature in general, particularly by suggesting the relationship between joint learning and the formation of firm boundaries. Joint learning is an essential process of acquiring and jointly developing knowledge in the context of R&D relationships, and thus acts as a motivator for high-technology companies to enter into partnerships with other firms. According to the competence boundary conception and the RBV, firms define their boundaries based on the external resource opportunities. This is particularly true in knowledge-intensive high-technology areas, but as suggested in the articles of this dissertation, external resources are not often available as such in the relationship, but must be jointly developed via the process of joint learning. Therefore, competence-based boundary formation is actually often based on learning opportunities rather than external resource opportunities. This is the first general theoretical implication of this dissertation. A second general implication is the observation that the practices and mechanisms of R&D collaboration affect both boundary formation and joint learning; processes that are strongly intertwined in practical long-term collaboration. Technological knowledge, shared experience, and tacit knowledge developed in the relationship accumulate over the years of collaboration. This in turn facilitates the process of joint learning and the development of mutual, personal-level trust in the relationship, which in turn helps the partners to collaborate more effectively. In this manner, the partners in a long-term collaboration learn to collaborate effectively, and therefore there is a positive link

between the RBV and TCA in R&D collaboration. A third general implication of this dissertation is the finding that identity- and experience-based reasons tend to dominate the decision making on organizational boundaries over other, more rational reasons such as competences or efficiency. A major reason for that might be the fact that R&D organizations operating in complex environments with rapid change often lack strategic guidelines. For this reason, this dissertation presents a theoretically grounded tool to assist organizations in this decision making (Article 4). The fourth implication relates to the dependence considerations in R&D relationships. The results of Article 1 reveal that mutual trust between the partners helps them to tolerate this dependence, and encourages the partners to engage in effective and close collaboration. This is particularly visible in relationships marked by high levels of interdependence. In addition, Article 2 considers the interdependence between the partners and reveals that mutual dependence actually facilitates embeddedness between partners, which in turn fosters effective joint learning and improved innovativeness in the relationship.

4.3 Practical implications

The results of this dissertation research suggest that technology organizations benefit from R&D collaboration with external partners in several ways. This collaboration provides the organizations with access to valuable external resources, capabilities, and skills that they lack. External collaboration can also help organizations increase the efficiency of, or share the costs or risks associated with, development activities. These are all good reasons to enter into collaborative relationships with external partners. Particularly for R&D units operating in the knowledge-intensive high-technology arena, external relationships provide an important channel of new and valuable knowledge that can be unique or tacit in nature. However, in many cases this knowledge is not available in the partnerships as such, instead, the partners can possess competences and skills that foster creating this knowledge in collaboration with the customer organization. Therefore, the creation of new knowledge is taking place in the process of joint learning between partners. This process requires long-term commitment, adaptation, and close collaboration from both sides of the partnership, but provides the partners with a way to generate sustainable competitive advantage through improved innovation performance. Relational joint learning also helps the partners to develop mutual trust and personal-level commitment in the collaboration; and both improve the efficiency of the relationship. Trust and personal-level relationships also help the partners to

tolerate dependence on the collaboration partners caused by the special and unique skills and competences provided by the relationship.

To efficiently develop knowledge creation capabilities, skills, and competences in the network of external actors, it would be beneficial to R&D managers to understand the most essential facilitators of innovativeness and technological knowledge creation, and Article 2 of this dissertation presents a number of specific factors and mechanisms that can help do so. First, in knowledge-intensive R&D relationships, the building of technological know-how and innovation capabilities is based on cumulative, jointly-created knowledge developed over years of collaboration. This process often gives rise to a mutual dependence between partners, which in turn ties the partners closer together via personal-level trust and commitment to the collaboration, as suggested in Article 1. This kind of embeddedness between partners is able to foster innovativeness and also efficient collaboration in the relationship.

Article 1 reveals an important managerial observation that is also suggested in the organizational literature: Managers tend to make decisions concerning the organization of the R&D work into internal and external tasks based on their personal, subjective interpretations, and experience rather than relying on rational reasoning. Article 1 reveals the factors and mechanisms that influence R&D collaboration between customers and suppliers based on four explanations for boundary formation: competence, efficiency, power, and identity. Based on each theory, Article 1 identifies factors shaping the collaboration, and suggests that the R&D managers responsible for external collaboration should take these factors into account when making decisions on outsourcing R&D work. To serve this end, Article 4 of this dissertation presents a practical managerial tool designed to support this decision making. The tool developed is based on the four theoretical conceptions presented in Article 1.

4.4 Limitations and future work

Organizational boundaries and learning in interorganizational R&D collaboration have both proved to be interesting fields of research with both theoretical and practical implications. However, like all studies, this dissertation has limitations that give rise to a number of new questions of future research. While each of the associated articles discusses the limitations and directions for further research, this section focuses on the suggestions of future work on a general level.

The comparative case studies presented in Articles 1 and 2 contain several interesting implications that open a number of new research questions to be

addressed. First, concerning organizational boundaries, the conceptions of power and identity were both found to have an essential role in defining the organizational boundaries and also characterizing the organizational practices related to collaborative relationships. As power has been shown to have an impact on both efficiency and innovation in the relationship, it would be interesting to inspect what kinds of relational mechanisms can be found behind power-based boundary decisions. Identity also carries great potential for research, since identity-based decisions could be steered by an organizational strategy, and valuable research results on the identity-based reasoning in R&D context would help to support its development. Accordingly, the role and impact of both power and identity conceptions should be examined in detail using both qualitative and quantitative research approaches. Second, as this dissertation shows that all four boundary explanations studied are interrelated and also facilitated by relational capital and joint learning in the relatively complex context of knowledge-intensive R&D collaboration, quantitative approaches could be employed to investigate those relationships. Such research might help researchers to better understand boundary formation in the R&D context and also to suggest practical implications that could have a certain strategic and operational meaning in technology organizations. Third, the new research stream initiated in Article 3, joint knowledge creation and learning in networked R&D collaboration containing both internal and external relationships, raises new questions for several research fields. For example, the interlinked role of motivation, competences, and capabilities in internal and external R&D collaboration could be a valid and interesting area worthy of more detailed investigation in both qualitative and quantitative forms. This kind of in-depth research could be used to validate and further examine the relational factors and the process presented in Article 2.

The discussion on the validity and reliability of the dissertation highlights the areas of future research on the general level. First, as the majority of the theoretical results are based on comparative case studies of a qualitative nature, the dissertation concentrates mainly on relational practices and mechanisms of R&D collaboration in supplier–customer relationships in a limited quantity of cases. Although the dissertation makes contributions to the existing literature by proposing new models and suggesting relational practices of theoretical and managerial value, it does not test theories quantitatively. The only exception to this is the quantitative validation of the relationship between the RBV and TCA in the R&D collaboration context presented in Article 3. Therefore, the results of the qualitative case studies are valid in their contexts, but their theoretical implications should be quantitatively tested to generalize them to a population of companies. For example, the decision tool presented in Article 4 should be

further validated by testing it in practical decision processes in different kinds of R&D organizations. Future research would also benefit from a longitudal research design examined in quantitative manner. Second, the data were collected from the Finnish high-technology industry, which may limit the generalizability of the results. Therefore the future research should examine the relational practices in other types of R&D organizations and cultures. Third, organizational boundaries were studied by using case study method based on four well-known organizational boundary explanations, and theoretical as well as practical conclusions were drawn based on them. For this reason, other types of qualitative research methods than case study method could be applied to understand the variety of factors influencing the boundary formation.

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Technovation 45-46 (2015) 15–28

Contents lists available at ScienceDirect

Technovation

journal homepage: www.elsevier.com/locate/technovation

Boundaries of R&D collaboration

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ARTICLE INFO

Article history:
Received 24 September 2014
Received in revised form
22 June 2015
Accepted 18 July 2015
Available online 26 July 2015

Keywords:
Research and Development
New product development
Organizational boundaries
Supplier involvement

ABSTRACT

Building on organizational boundary theories (competence, efficiency, power, and identity), this study examines the boundaries of R&D collaboration, based on a qualitative, comparative case analysis of six long-term R&D relationships within the supplier network of a leading multinational corporation that manufactures electrical devices and systems. The results reveal that competence development, facilitated by trust, enables joint learning and the creation of tacit knowledge in long-term partnerships, and has a central role in boundary formation. Competence and accumulated experience also improve the efficiency of the relationship, which has a central impact on decisions to continue or end the collaboration. Power conception, drawing on resource dependency theory, is dominant in boundary setting only in cases where trust or mutual dependence between partners is low. The boundaries set by identity are based on managerial sensemaking and prior experience, and they tend to be dominant for as long as external demands force managers to re-consider them. First, the study contributes to supplier involvement literature by utilizing firm boundary theories in the context of R&D collaboration. Second, the study contributes to firm boundary literature by complementing the theory with trust and joint learning approaches, and by examining the interplay between different theories. The results also suggest practices that should be at the forefront of managers' thinking when they consider their firms' relational development needs in the context of R&D collaboration. The results also highlight the importance of long-term experience and trust in facilitating collaboration in the relationship.

1. Introduction

Research and development (R&D) is a key source of competitive advantage for high-technology firms (Van Echtelt et al., 2008; Artz et al., 2010; Eng and Wong, 2006). Working under the pressure of highly competitive environments, characterized by rapid and unpredictable technological changes and short product life cycles, managers of high technology firms have to integrate, build, and reconfigure internal and external resources, capabilities, and competencies to address these environmental changes (Teece et al., 1997). In search of both competence and cost advantages, firms have extended their R&D activities across organizational boundaries and outsourced innovation work to suppliers (Johnsen, 2009; Wagner and Hoegl, 2006; Quinn, 2000). There is a need to develop a greater understanding of the characteristics and management of R&D work that crosses organizational boundaries (Johnsen, 2009; Davis and Eisenhardt, 2011). A central managerial challenge in R&D organizations is to make boundary decisions on which tasks and activities are performed by the focal organization (hierarchical governance), and which are to be outsourced (market governance).

As the existing empirical work on organizational boundaries in an R&D context typically utilizes single theories, such as transaction cost efficiency (Athaide and Zhang, 2011; Eng and Wong, 2006), competence (Verona, 1999; Yasuda, 2005), power (Gulati and Sytch, 2007; Mayer and Nickerson, 2005), or organizational identity (Tripsas, 2009), many of the earlier studies neglect the interplay between different boundary conceptions, particularly in the context of R&D relationships. This is surprising because, first, boundary decisions play a particularly important role in R&D relationships, where knowledge asymmetries are great, and second, because of the emphasis placed on the interplay between boundary conceptions by Santos and Eisenhardt (2005, p. 503), who suggested that the conceptions may coevolve and exert a joint impact.

This study intends to fill this gap by answering the following research question: *Which practices are related to firm boundary conceptions, and how do they interplay in long-term R&D relationships?* Using a qualitative comparative case study to analyze a network of R&D relationships, this study contributes to supplier involvement literature by utilizing firm boundary theories (Santos and Eisenhardt, 2005) in the context of R&D collaboration. Second, the study contributes to firm boundary literature by complementing the

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http://dx.doi.org/10.1016/j.technovation.2015.07.002
0166-4972/

organizational boundary theory with trust and joint learning approaches, and by examining the interplay between different boundary theories. A qualitative comparative case study was chosen for this study because that method permits in-depth interpretation when it is necessary to understand the dynamic mechanisms between boundary conceptions, as is the case when firm boundaries are defined and re-defined. By developing a framework to analyze boundary delineation in the context of R&D relationships, this study could enable firms to make consistent decisions on organizational boundaries in R&D work.

2. Theoretical background

Building on the theoretical background of firm boundary theories, the present study intends to contribute to the R&D supplier involvement literature. For effective R&D operation in a dynamic environment of knowledge-intensive, high technology industries, it is important for managers to understand which resources must be coordinated within the focal organization, and which can be obtained from the network to complement competencies, improve performance, share costs, and mitigate risks (Lavie, 2006; Eisenhardt and Schoonhoven, 1996). The present study uses organizational boundary theories to analyze how specific activities are coordinated between a customer organization and its R&D suppliers. Following the definition of Santos and Eisenhardt (2005), an organization boundary is the demarcation between the organization and its environment. Organizational boundary separates a legal organization from its environment, and thereby defines which activities are implemented within the organization and which activities are acquired from external organizations. The term conception refers to theory or approach. The literature usually cites four theories under the umbrella of the theory of the firm: resource-based theory, transaction cost theory, the power approach, and organizational identity. The firm boundary conceptions are summarized in Table 1.

2.1. Competence – the resource-based view

The conception of competence is based on the resource-based view (RBV) (Eisenhardt and Schoonhoven, 1996; Lavie, 2006), suggesting that firms are continuously searching for resources and processes (Long and Vickers-Koch, 1995) to configure combinations that function as a source of competitive advantage (Santos and Eisenhardt, 2005). In addition to a supplier's own resources, the resources provided by its partner network contribute to the focal firm's performance (Lavie, 2006; Gulati ,1998), which emphasizes the meaning of the R&D supplier's network capabilities. According to the RBV, resource configurations should be valuable, rare, inimitable, and non-substitutable (VRIN). As the resources are heterogeneous between firms, and imperfectly mobile (Eisenhardt and Schoonhoven, 1996; Lavie, 2006), firms have to complement internal resources with external ones, such as the R&D capabilities of a partner supplier. From the resource-based perspective, R&D partnerships are seen as a means to increase internal competences (Parmigiani and Mitchell, 2009), and to share the costs and risks of innovation (Eisenhardt and Martin, 2000). However, as the integration of R&D knowledge is challenging – because it is tacit in nature – joint learning is required to implement knowledge integration (Teece et al., 1997; Huikkola et al., 2013). In this study, joint learning is defined as a joint activity between the supplier and customer, where the parties share knowledge, jointly make sense of the knowledge, and integrate that knowledge into relational memory.

2.2. Efficiency – transaction cost economics

According to the efficiency conception, the costs of collaboration are important when considering whether the organization of R&D work should be based on an arm's length, a collaborative, or a hierarchical structure (Williamson, 2008; Rindfleisch and Heide, 1997). The efficiency conception is dominated by transaction cost economics that considers the costs of coordination resulting from the interplay between different dimensions (Santos and Eisenhardt, 2005), such as asset specificity, and environmental and behavioral uncertainty (Rindfleisch and Heide, 1997; Williamson, 1975, 2008). In R&D literature, it has been suggested that behavioral uncertainty is positively related to hierarchical governance, whereas high technological uncertainty favors market governance to mitigate obsolescence and preserve flexibility (Dyer, 1996), which is typical in rapidly developing high technology areas. On the other hand, the risk of opportunistic behavior by partners (Barney, 1999), in knowledge-intensive R&D collaborations, in turn tends to increase transaction costs (Rindfleisch and Heide, 1997). While supplier involvement may increase transaction costs in the short term, supplier involvement may also produce benefits, by saving future production costs. Moreover, the increased trust developed in the earlier stages of the relationship may lessen interaction costs in the future (Lewicki et al., 2006; Dyer and Chu, 2003). This therefore suggests that the competence view may outweigh transactional efficiency in terms of boundary formation in these dynamic environments (Santos and Eisenhardt, 2005, p. 499). Overall, the vast information asymmetries and resulting challenges for negotiations and monitoring, which are involved in R&D exchanges, increase governance costs, which then affect make-or-buy decisions (Kohtamäki et al., 2013). Therefore,

Table 1
Summary of firm boundary conceptions.

Conception	Theory	Drivers for relational organization	Mechanism	Key dimensions in R&D collaboration	Related interview questions
Competence	Resource-based view	Maximizing the value of the organization's resources	Tends to extend the firm boundary to maximize valuable competences and capabilities	Resource complementarities Mobility of the resources and capabilities Joint learning	A1–A2B1–B4
Efficiency	Transaction cost economics	Minimizing the costs of governing activities	Internalize when outsourcing is not efficient	Information asymmetries Behavioral uncertainty Monitoring and meeting practices Processes and agreements	A3–A4B5–B12
Power	Resource dependency	Maximizing strategic control over external forces by controlling strategic dependences	Internalize when dependence on external partners is too high	Customer's dependence on supplier Switching cost Mutual dependence	A5–A7B13–B14
Identity	Organizational identity, managerial cognition	Collective sensemaking of organizational members	Tends to maintain existing practices (status quo)	Managerial sensemaking	A8–A10

transaction costs, caused by monitoring and meeting practices, processes, and agreements (Rindfleisch and Heide, 1997), may have a significant effect on boundary decisions (Eng and Wong, 2006).

2.3. Power – resource dependency view

The power conception, that derives from the organizational economics and resource dependency tradition, concentrates on the power-dependencies between companies operating within value systems, and analyzes how organizations control the relationships they are involved in (Santos and Eisenhardt, 2005). Where dependence on external partners reduces a firm's bargaining power and increases its vulnerability to the partner's opportunistic behavior, firms favor reducing dependence when possible (Porter, 2008). In knowledge-intensive high technology areas, the firms are also often dependent on their partners' specialized and unique competences, capabilities, and skills that are difficult to substitute or imitate (Gulati and Sytch, 2007), and therefore make partner switching costly (Heide and Weiss, 1995). Consequently, firms either have to tolerate being dependent on suppliers to enhance R&D performance (Gulati and Sytch, 2007), or bring strategically crucial development projects in-house to avoid dependency, and then lose access to their partners' competences (Mayer and Nickerson, 2005). This leads to interesting considerations when high dependence (power) suggests internalization, yet competence dissimilarity suggests externalization. Power is likely to dominate in such situations, because the risks of dependence affect survival, whereas competence mismatches only limit competitive advantage (Santos and Eisenhardt, 2005, p. 499; Mayer and Nickerson, 2005). On the other hand, if the relationship is coordinated properly, the partners' mutual dependence (Davis and Eisenhardt, 2011; Gulati and Sytch, 2007) and trust facilitated by relational capital (Lewicki et al., 2006) may make it easier for a firm to tolerate dependency, in turn favoring a competence-based boundary formation. Power and efficiency conceptions often tend to provide overlapping boundary predictions in make-versus-buy decisions in a stable industry structure, in which efficient governance of a transaction is a modest aspect of boundary choice from the power viewpoint (Santos and Eisenhardt, 2005, p. 496). However, power and efficiency conceptions are most appropriate to different environments, since power shifts the analysis from discrete transactions in stable environments to strategic relationships in dynamic environments with well-identified and influential players (Santos and Eisenhardt, 2005, p. 497).

2.4. Identity approach

Emerging from a variety of sources, such as the founders' beliefs and institutional conditions, and evolving over time through strategic interactions among intra- and inter-organizational members, organizational identity addresses the origins and role of the shared values and norms that constitute the central and distinctive character of the organization (Dutton and Dukerich, 1991; Kogut and Zander, 1996; Brown and Starkey, 2000). Because organizational identity determines the firm's managerial attitudes and behaviors in inter-firm relationships (Weick et al., 2005), it also influences what the firm coordinates internally, and what externally, that is, how the firm defines its organizational boundaries (Santos and Eisenhardt, 2005). Therefore, in the case of strong organizational identities, identity may come to dominate other conceptions, and only drive decisions aligned with the existing identity. In managerial decisions, organizational members notice and interpret external stimuli aligned with their organizational identity (Tripsas, 2009), after which managerial cognition shapes managerial actions and interpretations through sensemaking (Walsh, 1995; Weick et al., 2005). Where the organizational identity facilitates strategic activity, it may also inhibit actions when managers ignore, reject, misinterpret, hide, or lose information that threatens the firm's self-concept (Brown and Starkey, 2000). Identity often outweighs other boundary considerations, because a boundary decision that challenges organizational identity is not easily accepted, even if there is evidence of, for example, increased governance efficiency or competence (Santos and Eisenhardt, 2005, p. 502; Brown and Starkey, 2000). Identity also often dominates power considerations. However, external circumstances, such as demands from external forces that provide critical resources may challenge the status quo created by organizational identity, which in turn may trigger managerial sensemaking on identity re-evaluation (Louis and Sutton, 1991), leading to boundary reconsiderations (Santos and Eisenhardt, 2005, p. 502).

3. Data and methodology

3.1. Comparative multiple case study

This paper is based on a multiple case study approach and examines six of the R&D supplier relationships of a leading multinational corporation operating in the area of electrical and electronic devices and systems. The customer organization studied is the corporation's leading R&D center, located in Finland. The suppliers in question are all located in Finland, and collaborate with the customer in different areas of product development, including the development, design, and implementation of software, hardware, prototypes, and documentation. The six suppliers were selected because they all interacted closely with the customer; all possessed valuable resources that complemented the customer's resources; and each of the collaborations had a long history (of ten years on average). Table 2 summarizes information on the supplier companies referred to in the cases. A comparative multiple case study is a suitable method for examining purchasing and supply management mechanisms, particularly in view of the complexity of evolving relationships and interactions in business networks (Dubois and Araujo, 2007; Beverland and Lindgreen, 2010).

3.2. Data collection

During the period January 2013–March 2014, we held monthly meetings with representatives of the customer, mainly at the customer's premises. The meetings involved discussions with senior executives responsible for product development, product management, and research, and were intended to collect general information on the customer's R&D activities and supplier involvement strategy. In the course of the meetings, a core team drawn from among the customer's executives was formed to assist with the research. This team consisted of the technology center manager (who is the leader of the R&D center in Finland) and three R&D managers responsible for supplier relationships, software development, and hardware development. In subsequent meetings, this core team was extended to include managers responsible for the product portfolio, and relevant research and product development projects.

The data collection procedure is illustrated in Table 3. In the first round, our intention was to understand how R&D work was categorized, either as an internal task, or as external work allocated to suppliers. The questions in the interview were based on the four relational theories presented in Section 2 – efficiency, competence, power, and identity – using a structured interview template containing ten questions (Appendix 2A). The interviewees were the core team, extended to include managers responsible for the product portfolio and for research. The interviewees worked as a group, and so had an opportunity to discuss each question and present their individual viewpoints.

The second round of the data collection was a pilot study to

Table 2
Description of the relational case companies and the participants of group interviews on the customer and supplier sides.

	Customer	Supplier A	Supplier B	Supplier C	Supplier D	Supplier E	Supplier F
Total revenue	2 444 M€	14 M€	67 M€	26 M€	1 M€	1 M€	30 M€
Number of employees	7000	200	1000	230	16	10	210
Main products/services	Manufacturing of electrical and electronic devices and systems	Embedded software development and R&D services	Engineering and information management services	Manufacturing and design of electronic devices and embedded software	Software and hardware development and related R&D services	Hardware and software development services	Electronics manufacturing services
Services provided to customer	–	Embedded system development, including software and hardware design. Testing services	Technical writing and documentation	Production test, system design, and hardware development	Hardware development in specific areas, and embedded software design	Hardware development projects in specific areas	Prototype design
Supplier's share of customer's external R&D budget	–	45%	8%	8%	18%	7%	3%
Customer's share of supplier's R&D service sales	–	10–15%	3–5%	5%	45%	20–30%	0.5%
Duration of the collaboration	–	14 years	12 years	8 years	4 years	10 years	Over 15 years
Local presence at customer's site	–	Yes	Yes	No	No	No	No
Participants in the case interview (supplier)	–	CEO[a]; team leader	Global manager for information management development; chief information designer	Technical project manager; business unit director	CEO; sales director; project manager	CEO; project manager	Project manager
Participants in the case interview (customer)	–	Technology center manager; R&D manager	Technology center manager; R&D manager	Technology center manager; R&D manager (2); project manager	Technology center manager; R&D manager (2); project manager	Technology center manager; R&D manager (2); R&D team manager	Technology center manager; R&D manager (2); R&D team manager

[a] In the pilot study.

Table 3
Summary of the interview procedure.

	First interview round	Second interview round	Third interview round	Fourth interview round
Goal	To understand the reasons for the allocation of product development work to internal and external suppliers	To deepen our understanding of the topic, and validate the questionnaire	To understand special characteristics of each case relationship	To confirm and further refine our conclusions by reviewing and discussing the interview results with customer representatives
Interview type	Group interview for customer executives	A pilot study for case relationship A	Case interviews for each relationship using group interviews	Group interview for customer executives
Questionnaire	Structured interview template containing ten questions based on firm boundary theories	Structured interview template containing questions related to theories of efficiency, competence, and power	Structured interview template containing questions related to theories of efficiency, competence, and power	Open questions related to central themes which arose from the interview data
Participants (Customer)	Technology center manager; 3 R&D managers; head of product management; research manager	Technology center manager; R&D manager	See Table 2	Technology center manager; 3 R&D managers; R&D team manager
Participants (Supplier)	–	CEO of case company A	See Table 2	–

improve our understanding of the management of supplier involvement in the customer organization. The pilot study increased our understanding both of the topic and of the appropriateness of the planned data analysis methods, and it also allowed us to develop and validate the interview template to be used in the case interviews (Yin, 1994). An initial structured interview template, covering questions based on relational theories, was designed in collaboration with the customer's core team, and used to collect data on the customer's relationship with the case company (Company A). Two members of the customer's core team, and the CEO of Company A, were interviewed. The interview discussions and data collected led to a final template comprising 14 case interview questions (see Appendix 2B).

The third case interview round involved group interviews with representatives of both the customer and the suppliers in each relationship. Those interviewees were selected based on their experience of, and responsibility for, the relationship (see Table 2). The customer nominated potential interviewees on the supplier side, to ensure the most appropriate people were involved. The interviews lasted between 61 and 250 min, and were recorded. The respondents were key decision makers in the relationship, and were interviewed in groups to encourage consensus on the answers. In summary, we conducted 12 case interviews, with groups containing between one and four people. The interview data were analyzed when the case interviews were completed. The analysis below identifies the informants only by position and firm type, to preserve the confidentiality of the information.

The interview content and data collected were interpretative in nature, as the interviewees held their own views on the relationship, its history, the capabilities involved, and the key practices. However, these issues were controlled and discussed during the data collection process.

3.3. Reliability of the study

To increase the reliability of the study, a data triangulation technique was applied (Beverland and Lindgreen, 2010; Huberman and Miles, 1994; Huikkola et al., 2013), that involved harvesting data from firms' websites and annual reports, both before and after interviewing the supplier and customer. In addition, supplier's responses were compared to those of the customer, and vise versa, as suggested by Brennan and Turnbull (1999), as a validation guideline for relational studies that involve interviewees from both sides of the relationship. After the analysis of the case interviews was complete, an additional interview round was conducted with the customer's core team, to review, discuss, and reflect on the results. In the final interview round, open questions were posed to validate our conclusions. These related to the central themes emerging from the interview data. Finally, the interviewees received the final report and developed conclusions for revision and comment.

4. Results

The present study set out to analyze R&D relationships by applying four firm boundary theories, in order to understand the firm boundary definition in R&D collaboration.

4.1. Relational case description and within-case analyses

In terms of volumes, the relationship with supplier A is particularly significant for the customer, because almost half of the R&D purchase budget is allocated to that particular collaboration. This relationship concentrates on developing systems critical to the customer's products. The customer is to some extent dependent on the

supplier, but the supplier can be viewed as adding to the customer's product development capacity. Long-term collaboration has generated valuable relationship-specific expertize for both partners. Most of the supplier's employees work in the customer's R&D teams and are located on the customer's premises, and report directly to the project management function of the customer.

Relationship B was established when the customer divested its technical writing operations to a separate firm. Currently the supplier supports the customer in its strategic activities by providing documentation and information management services on a global scale. The relationship operates effectively as most of the supplier's employees were formerly the customer's employees. The supplier has considerable experience of the customer's processes, and has been able to expand the relationship into new strategic areas.

In relationship C, the supplier provides highly technical services related to production testing, which is a critical part of the customer's manufacturing process. The supplier's competencies result from long-term experience of projects with the customer. Those skills enable the supplier to provide added capacity for the customer's R&D function. Having resources available for the design of test equipment is critical for the supplier and the customer, and recruiting competent new employees is particularly challenging in this area of competence.

By conducting knowledge-intensive hardware system design for the customer, the supplier in relationship D complements the competences of the customer in certain technology areas critical to its current product portfolio. The relationship has lasted four years, but is based on prior collaboration between some key members currently working in case company D. The supplier is relatively small, and collaboration with the customer accounts for almost half of its turnover.

In relationship E, the supplier is specialized in a relatively unique technology area. The supplier has invested significant amounts of money in technology development in this area, and a major part of that development has been carried out in collaboration with the customer. The customer does not currently have an internal development facility or competences in this area, despite the fact that the area is important to its technology. It would be difficult to find other suppliers possessing these skills, or even with the capacity to develop them in the short term.

Relationship F was established when the customer outsourced its prototype manufacturing operations to a separate firm that took over the relevant production lines more than 15 years previously. The parties have collaborated since then and the supplier has been the exclusive provider of the prototype hardware used by the customer in product development. Despite the fact that there are several suppliers that could provide such services, the customer has expressed its desire to continue the collaboration with this supplier, citing the supplier's lengthy experience with the customer's products, its flexibility, and its short response times as among the reasons for the choice. Table 1 describes the findings in each relationship.

4.2. Cross-case analysis

To identify differences and similarities in the studied cases, the data are here analyzed across all of the cases. Eisenhardt (1989) argued that cross-case analysis forces researchers to go beyond their initial impressions, thereby increasing the probability of their capturing novel findings from the data. This cross-case section illustrates how competence, efficiency, power, and identity can explain how R&D work is organized in relationships between firms.

4.2.1. Competence

Technological capabilities are often seen as a primary driver of R&D outcomes (Verona, 1999; Wagner and Hoegl, 2006), and the customer representatives agreed that the availability of competences and capabilities clearly steers R&D work:

> We definitely want to find the best possible competences for each task. This discussion is often conducted on a personal level, and we consider who is the best possible person to perform a particular task. Whether that person belongs to our internal team or to the partner is a side issue (R&D Manager, Customer).
>
> Throughout the history of our company, our main goal has been to recruit people who possess the best competences to address the needs of local industry (CEO, Supplier).

Technological alliances can be described as networks of resources driven by a logic of strategic resource needs and social resource opportunities (Gulati, 1998). Interestingly, our data demonstrated a strong relationship between competence and transaction efficiency. Competences and technical knowledge obtained in joint development work have a clear impact on governing cost. A long-term collaboration, where experience is accumulated, can result in more efficient collaboration in future projects (Van Echtelt et al., 2008; Sobrero and Roberts, 2002; Verona, 1999). It seems that each relationship has a learning curve, where what is learned is mutual collaboration. On the other hand, effective transactions require that the buyer has clarified the need to balance the existing knowledge asymmetries.

> In my field, I have often noticed that the partner with the best competences is usually the cheapest one, when the total cost of the project is considered (R&D Manager, Customer).
>
> Our main goal is to keep the competence of our staff as high as possible, so that they are competitive in the customer's organization, compared to the customer's internal personnel. This means constant in-job learning, though, for example, rotation in different projects of various customers (CEO, Supplier).

Hence, the supplier has an opportunity to develop the competences of its R&D personnel by rotating R&D personnel around different customer projects. Multiple customer projects enable the supplier to operate as a knowledge broker, and utilize structural gaps that appear in the customer's project organizations to place its staff. The case interviewees also emphasized the role of appropriate resource configuration in the R&D network. Experience accumulated over the long-term (Van Echtelt et al., 2008) and tacit knowledge, including intangible factors embedded in personal beliefs, experiences, and values (Inkpen, 1996), is obviously valuable (Verona, 1999), and facilitates joint learning in the relationship (Selnes and Sallis, 2003; Kale et al., 2000; Kohtamäki et al., 2012). Long-term partnerships are often based on relationship-specific knowledge, which is difficult for incumbents to copy.

> In most of our fields of operation there are several companies that could potentially compete for the tasks that we are outsourcing. However, it is necessary that the supplier can wholly adapt to our technology area, so that it can really serve us as a developer. This is possible only when the supplier has experience of our projects (R&D Manager, Customer).
>
> We have been involved in the customer's projects in this specific area for several years. Hence our employees have very good insight into the customer's needs, requirements, and ways of working (Project Manager, Supplier).
>
> It is true that there are several other players in this field who can provide the customer the same kind of competences as we do. However, our developers have long experience of the customer's technology. This kind of competence cannot be found among our competitors (CEO, Supplier).

The networking performance and networking capabilities (Hagedoorn et al., 2006; Ritter and Gemünden, 2003) of the

supplier were also seen as valuable. Network resources, provided by the supplier firms with their partners, contribute to the focal firm's performance (Lavie, 2006; Gulati, 1998; Kohtamäki et al., 2013). Interview results show that a supplier can deploy its network to provide added value to the customer in terms of competence and technology development.

> Our company actively explores and exploits new technologies and R&D tools from different forums worldwide. We present and demonstrate them to our customers, and together consider how we could apply them in the customer's projects (CEO, Supplier).
>
> This supplier actively sources new skills from universities and other companies, and brings them to our projects. We sometimes recruit people from the supplier who have proved good at the project work. The supplier also sometimes recruits R&D people from us and uses them in our projects. I think that this has been a real win-win in the sense of resources (Technology Center Manager, Customer).

The data highlight the importance of boundary actors operating across organizational borders, and also demonstrate an important practice related to boundary spanning activities: the customer recruiting the supplier's former staff who have experience of working on projects with the customer. Staff movement in the opposite direction also occurs. The practice enables supplier and customer to adjust their resource bases, and at the same time exchange competences. This kind of joint adjustment of the resource portfolio of two firms has a strategic meaning for both parties, and requires a deep alliance relationship between the firms, and open discussion when recruiting from the other partner's side. Another example of this kind of development is the outsourcing exemplified in case B that had a positive performance impact.

> We outsourced our technical writers to an external company [case company B] about 12 years ago. Many of those people are still working on our projects. This is very beneficial from our point of view, because their experience is valuable in documentation, and as they work for an external company, they have been able to gain competences and skills in other projects too. Moreover, we investigated the financial impact of this outsourcing a while ago, and found that it has brought remarkable cost savings (Technology Center Manager, Customer).

Again, it is apparent that a supplier can provide improved competences and skills to a customer by rotating its staff around other customer projects, where the actors learn skills and practices that can be transferred to the customer. If the technical writers mentioned here had remained with the customer, this would probably not have been possible.

To summarize, competence is perhaps the most important conception in this context, mainly due to its strategic meaning in product development, where the organizational learning and technological competencies facilitate technological knowledge creation across organizational boundaries. Accessing the best possible skills, competences, and resources to be applied in each task has a central importance when organizational decisions are being made.

4.2.2. *Efficiency*

Transaction cost economics suggests relational efficiency should be inversely related to the magnitude of the cost of negotiating and writing contracts, and to the cost of monitoring and enforcing contractual performance (Leiblein and Miller, 2003; Kohtamäki et al., 2012). The customer's executives clearly expressed the benefits of the supplier having prior experience of working with their firm, which positively affected anticipated governance costs, and reduced behavioral uncertainty (Gulati and Sytch, 2008; Rindfleisch and Heide, 1997; Van Echtelt et al., 2008).

> We do not want to waste our resources on unnecessary project management or governing activities. Therefore we want to have partners with whom it is easy to collaborate and who do not need any additional steering or control. In fact, our current long-term partners have been selected based on this principle. On the other hand, collaboration with some partners has ended for this same reason (R&D Manager, Customer).
>
> Our long-term partners have valuable experience with our projects. Our employees know the supplier's key staff well, which enables open and free discussion. This makes collaboration easy and effective (R&D Manager, Customer).

The customer relies on its long-term partners, and that reliance has a positive impact on efficiency (Van Echtelt et al., 2008; Dyer and Chu, 2003). However, over-emphasizing the importance of previous experience and familiarity may limit the ability to explore new opportunities:

> Perhaps we think of the cost of governing the relationship too much we have almost always selected a trusted long-term partner for new projects, based on its efficiency. This means we may be ignoring some potential new partner candidates that we do not yet know, but who could bring new capabilities and know-how to our R&D (Research Manager, Customer).

Mutually agreed practices are important for the relationship, because the supplier needs to adapt to the customer's internal processes and tools. Partner-specific adaptations are a representation of past events, activities, and decisions encapsulating common experiences, and therefore facilitate the conduct of further business (Walter, 2003). Adaptation ties suppliers more closely to the customer, and thereby supports interaction and creates entrance barriers for competing firms (Brennan and Turnbull, 1999; Walter, 2003).

> It is very important to us to maintain long-term relationships with partners who are able to follow our R&D processes, use our R&D tools, and who can adapt to our way of working (Technology Center Manager, Customer).

Adaptation on the part of the supplier in the relationship requires trust and commitment to the customer. Adaptations, in turn, feedback into increased trust in, and commitment to, the relationship on the customer side (Brennan and Turnbull, 1999). Another measure of trust in the relationship is the role of written agreements, which are also key to governing cost (Santos and Eisenhardt, 2005; Leiblein and Miller, 2003). All the interviewees agreed that there was little need for written agreements; indicating a high level of trust in all six relationships.

> We trust our supplier, and we have found that all the issues proceed smoothly based on informal agreements. In practice, this means that we agree the tasks to be done in the project meetings, and the supplier performs the tasks as agreed (R&D Team Manager, Customer).
>
> Based on our experience, we have very high trust in the customer. For this reason there is no issue with carrying out tasks without written agreements (CEO, Supplier).

Interviewees underlined the importance of mutual trust, which has a positive impact on efficiency in terms of reducing the transaction costs associated with written agreements (Zaheer et al., 1998; Dyer and Chu, 2003). When considering effective practices, it was also apparent that, within projects, the customer purchases services from the supplier based on relatively broadly-defined budgets. The customer indicated that it could be difficult to define the services to be purchased, but that long-term

relationships, and trust in the supplier facilitated effective negotiation and service purchasing. These results reveal that trust enables partners to share strategically important knowledge, discuss issues openly, and to share detailed ideas (Kohtamäki et al., 2013; Stump et al., 2002). Our case interviews indicate that having clear responsibilities on both sides, and holding regular project meetings, facilitates efficient project management (Rindfleisch and Heide, 1997). The customer recognized the need for weekly meetings to effectively manage and control the project work.

> Our project manager collaborates closely with the customer's project manager. Problems can usually be solved with one phone call (CEO/Supplier)
> The supplier's project manager may have several parallel projects going on at the same time, which may occasionally cause delays. However, we are also sometimes very busy and we need to prioritize tasks internally. This causes delays in meetings or information sharing with the supplier (R&D Manager, Customer).
> We have a regular weekly teleconference with the customer. Right before it, we have an internal meeting in which we create a status report that we go through with the customer in the weekly meeting. This is an effective way of governing the project (Project Manager, Supplier).

Joint meetings are easier to arrange and more effective with partners operating in physical proximity to the customer. Such meetings are important because of the conceptual and tacit nature of the knowledge required in joint R&D projects. Finding a common understanding requires discussion and what can be termed a psychological proximity (Kogut and Zander, 1996). In-depth interactions facilitate the joint sensemaking necessary for knowledge development (Huikkola et al., 2013). Collaboration is particularly seamless in relationship A, where the supplier's employees work on the customer's premises.

> Most of the employees of this partner [Partner A] work on our premises and are members of our R&D teams under our project management. Interaction is therefore very close, and there is actually no need to govern the project between ourselves and the partner (R&D Manager, Customer).
> Our developers work directly under the customer's project management. In this kind of setup, information sharing is seamless between us and the customer. All the daily issues can be jointly discussed and resolved instantly (Team Leader, Supplier).

In the studied cases, investments in relational-level IT systems are important in facilitating product development work. The level of access to the customer's IT system varied by supplier, and some suppliers clearly stated that the lack of access to relevant tools caused some issues in R&D work.

> Currently we do not have access to those IT tools that we would need in our everyday R&D work. For this reason, we need to ask for information [that is available in the IT system] from the customer by e-mail. This causes delays and additional work on both sides. It also increases the risk of errors in our designs (Project Manager, Supplier).

The interviews revealed that formal process descriptions were rarely followed and updated. Such process descriptions may not be feasible in a complex product development work environment where the working procedures of the different actors are heterogeneous (Corsaro et al., 2012), and where direct personal relationships support straightforward communication.

> Issues related to responsibilities, communications, and other issues of this kind have been informally discussed with the supplier. We have not created any official process description or responsibility table. We discuss these issues in our regular project meetings, if necessary (Project Manager, Customer).
> Collaboration in the projects with the customer has evolved over the years and everyone quite clearly knows their roles and responsibilities. We go through all the actual issues and make decisions in our meetings. I do not feel that official processes should be created to steer this (Project Manager, Supplier).

To summarize, transactional efficiency, facilitated by competence, inter-dependencies, and trust, plays a central role in boundary considerations, where competence differences may prohibit insourcing, transaction costs prohibit buying, and trust is used as a coordination mechanism to increase the effectiveness of long-term R&D collaboration. The efficiency conception, which highlights governance costs, has a central role when making decisions on organizational boundaries in R&D collaboration.

4.2.3. Power

Strategic control over external forces can be considered an action intended to reduce dependence (Santos and Eisenhardt, 2005). In R&D, dependence is often a consequence of the supplier having unique (and therefore difficult to imitate) competences that are also highly valuable to the customer. Our data were particularly consistent in this respect. Representatives of the customer felt that controlling the dependence on a supplier's competences was important, but they did not control that dependence by maintaining several sources in each technology area. Instead, they preferred to maintain their internal competences.

> The primary goal is to develop and maintain our own, internal capabilities and competences in our core business area, to avoid dependence on our suppliers (R&D Manager/Customer).
> There are some critical areas where we would like to improve our internal competences. However, as there is an external partner that already has these skills, we usually take the easy decision and outsource this piece of development work to this supplier (Technology Center Manager/Customer).
> We do not need to maintain second sources just because of the risk of dependency. We protect ourselves from dependency by maintaining internal competences in critical areas (R&D Manager/Customer).

The meaning of long-term, trusted partnerships was again apparent. We found that the customer tolerated dependence on those suppliers it had a close personal relationship with, more than it would with less familiar suppliers. Previous positive experiences, and familiarity with the supplier, were felt by the interviewees to reduce behavioral uncertainty. This is aligned with reports that dependency is often felt to be controlled by trusting, open relationships, that engage partners in a psychological contract (Gulati and Sytch, 2008; Rindfleisch and Heide, 1997; Van Echtelt et al., 2008). Our case interviews underlined the importance of the interdependence between customer and suppliers. Interdependence can be seen as an interrelated notion of power and control, where one party cannot derive benefit without contributions from other parties (Gulati and Sytch 2007). Mutual interdependence was particularly strong in relationships D and E, where the customer's business formed a very significant share of the supplier's sales, and the customer was dependent on the suppliers' competences. It seems that the level of trust in these strongly interdependent relationships is particularly high, and there is a willingness to behave in ways that serve the interests of both parties. Trust is considered a facilitator of effective cooperative behavior in these relationships (Selnes and Sallis, 2003; Kale et al., 2000; Kohtamäki, 2013).

> Our dependence on this supplier is high because we do not have internal competence in the technology area provided by

this supplier, and it would be relatively difficult to generate. However, we trust this supplier, and based on our experience we believe that the collaboration will continue in a good spirit (R&D Team Manager, Customer).

We know that the customer is dependent on our special competences, which would be very difficult to replace. However, we are also dependent on the customer because it is our biggest customer and this relationship is therefore extremely important to us. In addition, working on the customer's projects allows us to develop our internal core competences in the best possible manner (CEO/Supplier).

In this relationship, both sides can rely on each other, and we can perform the tasks that have been agreed. This way, we can make the relationship effective (Project Manager/Supplier).

Hence, the data demonstrate that trust, in parallel with mutual interdependence in long-term relationships, can be seen as a balancing mechanism to dependence. Trustworthy relationships, resulting from systematic use of trust as a coordination mechanism (Adler, 2001), enable the customer to maintain competence-intensive relationships with suppliers even if there is strong dependence in the relationship.

4.2.4. Identity

The conception of identity is based on two different theoretical streams (Santos and Eisenhardt, 2005). The first is managerial cognition, which means managers' actions and interpretations of the world (Weick et al., 2005; Walsh, 1995). Managers absorb, process, and disseminate information about opportunities and problems, to facilitate strategic decision making in highly ambiguous environments. The process is based on collective sensemaking through awareness of new information, prior actions, and environmental changes (Weick et al., 2005). The decisions to outsource product development work to suppliers are an example of such a strategic choice:

It would be easy to make a decision that all the work that does not belong to our core business area will be outsourced. However, it is not so easy to define the core business in our field. Actually, we should have an internal discussion on this and devise a clear strategy for our core business. (R&D Manager/Customer)

In the past, display development was outsourced because it was not regarded as important. However, we have now reconsidered this, because any quality issues related to displays are very serious in terms of our products' usability, and therefore we may need to take the development in-house to safeguard the quality (Technology Center Manager/Customer).

Another theoretical stream is based on the role of shared values and norms in organizational identity (Santos and Eisenhardt, 2005). In this view, an organization's identity guides and activates individuals' motivations for action (Dutton and Dukerich, 1991). We did not find evidence that motivational factors would steer the organization of the work. On the other hand, organizational traditions do seem to play a role in this context.

Our organization is quite technology-oriented, and employees have a personal interest in new developments in this area. However, there are many examples of tasks that have been outsourced, despite our R&D team members being eager to undertake them themselves. On the other hand, we do conduct certain tasks (e.g., maintenance work) internally, despite the fact that the R&D staff is not at all interested in them. (R&D Manager/Customer).

Identity often dominates boundary considerations over other conceptions (Santos and Eisenhardt, 2005, p. 502), because managers are likely to ignore or misinterpret evidence of increased relational efficiency, competences, or power, if it challenges their own, identity-based views (Brown and Starkey, 2000). Moreover, since identity becomes intertwined in the routines, procedures, and beliefs of both organizational and external constituents, efforts to shift identity, in order to accommodate identity-challenging technology, are difficult (Tripsas, 2009). The results of this study confirmed the notion of (Santos and Eisenhardt, 2005, p. 502), that identity-based reasons often outweigh boundary decisions, even when clear evidence suggests that alternative decisions would be more appropriate. Thus, identity may maintain boundaries, to an extent, when external forces or other critical factors trigger identity re-evaluation that could lead to boundary reconsideration (Santos and Eisenhardt, 2005, p. 502; Louis and Sutton, 1991).

If some practice (e.g., outsourcing activity) has been proven to work well, it tends to continue without regular reconsideration. There are certain areas of R&D that we have got used to handling by ourselves, even if those tasks could be outsourced. Similarly, some tasks that have traditionally been outsourced would perhaps be more feasible to carry out internally. This way, tradition steers make-or-buy decisions in some cases more than rational reasoning. (R&D Manager/Customer)

In addition, traditions and policies determined higher up the hierarchy, though not rationally underpinned, may also play a dominant role.

We sometimes have to make a decision on outsourcing an important task because we cannot allocate our internal resources to it, even if we feel that we have the best competences for it. Typical reasons for that are corporate policy or priorities set at the upper levels of the organization. (Technology Center Manager/Customer)

In some cases we have been forced to outsource tasks that we would have wanted to carry out ourselves because we have not been allowed to recruit people to this task. (R&D Team Manager/Customer)

Hence, upper level managerial sensemaking may differ significantly from that at lower levels of the organization, and this may lead to boundary settings where strategy becomes separated from operations, and where those boundary settings are neither practical nor useful.

5. Discussion and conclusions

5.1. Theoretical implications

Building on relational theories (Santos and Eisenhardt, 2005), this study extends the supplier involvement literature by analyzing long-term R&D collaboration through the application of four boundary conceptions based on the interplay between organizational theories (Table 4). The analysis of the six relational cases revealed that, based on the conceptions of competence, efficiency, power, and identity, it is possible to identify several factors to explain boundary formation between customer and supplier. In addition, the results suggest that these conceptions are connected to each other via mutual trust and joint learning, which play a facilitating role in determining practicalities in the collaborative relationship between customer and supplier (Fig. 1).

Our results indicate that competence has a very central role in defining the collaborative relationship between a customer and its suppliers. Building on the principles of the RBV, an organization's internal resources are matched with environmental opportunities, which has a positive impact on competitive advantage (Eisenhardt and Schoonhoven, 1996). The results emphasize the meaning of

Table 4
Summary of the interplay of boundary conceptions.

Conception	Competence	Efficiency	Power	Identity	Trust	Learning
Competence	–					
Efficiency	Partner's competence improves efficiency.	–				
Power	Competence increases power. Trust enables competence-based boundary choice even in cases of high dependency.	Power may decrease transaction costs. Balanced power positions may increase transaction costs.	–			
Identity	A clear identity may offer potential for greater competency, and competency enables specific focus and identity.	Clear-cut identities increase focus and hence increase outsourcing. Complementary identities may improve collaboration and decrease transaction costs.	Partners' use of power may force managers to re-consider their identity-based views.	–		
Trust	Competence increases trust, whereas trust facilitates joint knowledge development through improved knowledge sharing.	Trust decreases governance costs in the relationship.	Trust balances the exercise of power between partners.	Trust facilitates specialization and better delineated identity	–	
Learning	Learning enables competence development and resource reconfiguration.	Learning facilitates finding shared understanding, so decreasing governance costs in the relationship.	Learning may increase stability of the use of power.	Clear identity may facilitate learning and innovation, whereas learning may reveal a well-defined identity	Trust and learning interact positively	–

suppliers' specialized and unique competences and capabilities, which are difficult to substitute or imitate, but which are essential to the customer's product development outcomes and competitiveness. These complementary resources, and especially technological knowledge, accumulate in the relationship over the years of collaboration. This shared experience and tacit knowledge facilitates joint learning in the relationship, and is also likely to result in more efficient collaboration on future projects (Van Echtelt et al., 2008; Sobrero and Roberts, 2002; Verona, 1999). Our key finding is that this is the mechanism for maintaining and further developing mature, long-term collaboration in the R&D supplier relationship.

The results revealed several factors pertaining to relational efficiency and consequent governance costs, such as a partner's experience, knowledge and adaptation; project monitoring and meetings; relational process development; and finding consensus between partners (Rindfleisch and Heide, 1997; Van Echtelt et al., 2008; Gulati and Sytch, 2008). These factors were regarded as important reasons for organizational decisions affecting firm boundaries in dynamic high technology environments. This is a somewhat contradictory finding with respect to previous research, which asserts that transaction cost theory is relevant only when analyzing static efficiency and routine situations (Gulati, 1998), and that competence often outweighs efficiency in dynamic environments (Santos and Eisenhardt, 2005, p. 499). Our findings suggest that competence actually improves transactional efficiency, as partners in the joint experience learn to collaborate effectively. Our results also strengthened the evidence from earlier research that, because trust alleviates the fear of opportunism, it is able to reduce governing costs caused by behavioral uncertainty in the relationship (Zaheer et al., 1998; Dyer and Chu, 2003). On the supplier side, trust facilitates commitment, which has a positive impact on the supplier's adaptation to the customer's processes, and increases relational capital, which, in turn, is a driver of trust in the relationship (Selnes and Sallis, 2003; Kale et al., 2000). This is likely to reduce the governance costs of the relationship and positively affect the decision to continue it (Brennan and Turnbull, 1999). On the other hand, results clearly indicate that high governance costs have triggered decisions to end relationships with particular suppliers, despite their possessing valuable competences.

Power conception concentrates on relational dependencies. Our results highlight how dependencies in R&D relationships are mainly caused by suppliers having special competences that their customers do not possess internally, but which are critical to that customer's competitiveness. Previous research suggests that technology collaborations often form between partners that are mutually dependent (Davis and Eisenhardt, 2011; Gulati and Sytch, 2007). This is particularly relevant in knowledge-intensive R&D work that utilizes special competences derived from external sources. Small suppliers, providing some special competence, are often very dependent on their largest customer, who is, in turn, dependent on the small supplier's competences (Gulati and Sytch, 2007). Our results support this notion, and also indicate that mutual trust is particularly high in this kind of relationship. The partners trust each other's loyalty to the relationship, which reduces the fear of opportunistic behavior from either side. To some extent, our findings therefore contradict those of previous studies, which indicated that power outweighs competence, and suggested that internalization occurs when external dependence is high, regardless of competence considerations (Santos and Eisenhardt, 2005, p. 499; Mayer and Nickerson, 2005). Instead, this study indicates that mutual trust in the relationship (Lewicki et al., 2006) enables competence-based boundary formation, regardless of high dependency.

In identity conception, managerial cognition and collective sensemaking are the primary drivers of organizational boundaries (Weick et al., 2005; Walsh, 1995). Our empirical work confirms the finding of Tripsas (2009) and Brown and Starkey (2000), that managers' personal, identity-based views and organizational

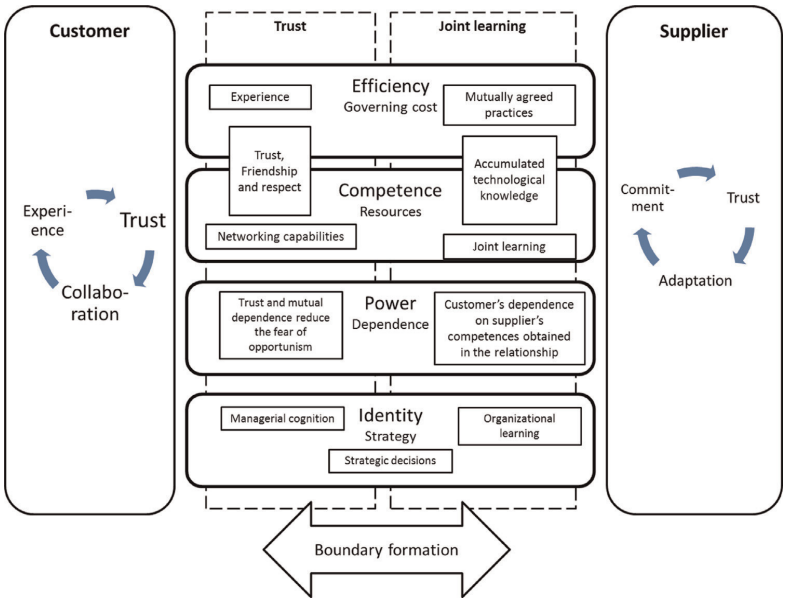

Fig. 1. Factors affecting boundary formation in long-term R&D collaboration between customer and suppliers.

traditions may outweigh boundary considerations, even if they are irrational. These views are often based on prior experience of collaboration with a supplier, but lack a systematic, rational decision process to support them. Boundaries set by identity tend to persist until external forces compel managers to re-consider their identity-based views, where those views are based on managerial cognition, sensemaking (Brown and Starkey, 2000; Santos and Eisenhardt, 2005, p. 502), and the interpretation of information from various sources (Walsh, 1995). On the other hand, a well-defined identity can improve the focus of the organization, which in turn may yield to improved competences and more efficient collaboration (Santos and Eisenhardt, 2005, p. 502). Our findings support the use of objective analysis methods in organizational decision making that could question accepted practices and conventions, based on rational reasoning. A natural guideline for managerial decisions in this context would be an organizational strategy that could steer identity-based decisions. However, this kind of strategic guideline is often lacking in product development organizations operating in complex and rapidly changing environments.

5.2. Managerial implications

Managers make decisions based on their interpretations of the environment (Daft and Weick, 1984), and these interpretations can result from identity-based, personal, subjective views, or from concrete factors related, for example, to competences, resources, dependence, or transactional efficiency. To make decisions on the organization of work, based on relevant arguments and reasons, managers should be able to understand the rationale behind organizational boundary conceptions. This study reveals specific factors that affect relational R&D collaboration. The factors were determined based on four different boundary theories: competence, efficiency, power, and identity. We have identified factors related to each theory that influence how the collaboration between customer and supplier is shaped. Our results also highlight the importance of long-term experience and trust in facilitating collaboration in the relationship. The findings of this study suggest that managers responsible for R&D supplier involvement should take a wider range of factors into account when making decisions on how that involvement is organized. Instead of concentrating only on one perspective, such as efficiency or competence, it would be beneficial to consider the factors affecting the decision from all of the viewpoints used in this study. To this end, it would be relatively straightforward to use the results outlined in this paper to design simple decision support tools.

5.3. Limitations and future research

Boundary formation in long-term R&D supplier–customer relationships has proved a valid area of research. The results of this study give rise to several new questions for further research, the first of which is the supplier viewpoint. It would be interesting to analyze how relationships are set in the customer network of a supplier company providing R&D services. This could be a topic for a case study using qualitative data. Another interesting topic for further quantitative research would be to investigate how efficiency, competence, and power conceptions are interrelated in this context, and how mutual trust facilitates those interrelations. A third potential direction for further research might incorporate a more systematic analysis of identity-based decisions in organizational boundary decisions. We believe this to be an important topic, because identity-based decisions could be guided by an organizational strategy, and good quality research data would help to support its development.

Acknowledgements

This paper is a product of FUTIS (Future Industrial Services) research project. The financial support of the Finnish Funding Agency for Technology and Innovation (Tekes), Fimecc and companies involved is gratefully acknowledged.

Appendix 1

See Appendix Table 1

Appendix 1
Within-case table based on case interviews.

Topic	Supplier A	Supplier B	Supplier C	Supplier D	Supplier E	Supplier F
EFFICIENCY						
1. How is project management organized?	Because most of the supplier's employees work on the customer's premises as R&D team members, there is no need for a project manager on the supplier side.	There is a project manager nominated on the supplier side, who is in contact with the customer's documentation manager and product program manager.	Project managers on both sides share responsibility for the projects.	Project managers on both sides share responsibility for the projects.	There is a project manager on the supplier side. On the customer side, responsibility is shared by several managers.	Project managers on both sides share responsibility for the projects.
2. Steering and controlling of daily/weekly work.	A regular weekly meeting is organized by the customer's project manager.	A regular weekly meeting is organized by the customer's documentation manager.	A regular weekly meeting is organized by the customer's project manager.	A regular weekly meeting is organized by the customer's project manager. Supplier has an internal project meeting just before this weekly meeting.	A regular weekly meeting is organized by the customer's project manager.	The nature of the projects makes weekly meetings unnecessary. Project managers are in touch as and when required.
3. The ways of working and processes in the relationship.	There is no official process description, but the practices have evolved over time.	An official process description exists.	An official process description is based on the customer's milestones.	An official process description exists.	Responsibilities are written in the project plan.	An official process description is based on the customer's milestones.
4. The use of common IT tools in the relationship.	The supplier has access to the necessary tools in the customer's IT system.	Some of the supplier's employees have access to the customer's IT system.	Some of the supplier's employees have limited access to the customer's IT system.	The supplier does not have access to the customer's IT system.	The supplier does not have access to the customer's IT system.	Currently there is no need for access to the customer's IT system.
5. Have the actions been performed as agreed, and have the agreed timetables been followed?	There have been no delays caused by the supplier. Mutual trust is strong.	There have been no delays caused by the supplier. Mutual trust is strong.	In the past, there were some problems in the timing of tasks.	There have been no delays caused by the supplier. Mutual trust is strong.	There have been some delays caused by the supplier.	There have been some delays caused by the supplier's production control system and component providers.
6. Need to control the deliverables.	All deliverables are routinely controlled and reviewed.	All deliverables are reviewed as agreed. Documentation requires a careful review process.	All deliverables are routinely controlled and reviewed. Additional controls needed occasionally.	All deliverables are routinely controlled and reviewed.	All deliverables are routinely controlled and reviewed.	All deliverables are routinely controlled and reviewed.
7. Need to steer the supplier.	The projects proceed smoothly. There is no need for additional steering.	The parties know each other's practices and processes. There is no need for additional steering.	The customer has given considerable feedback and input into the designs.	There is considerable interaction due to the nature of the project.	There is no need for additional steering.	There is no need for additional steering.
COMPETENCE						
1. Are the supplier's competences/resources particularly special and unique in the market?	There are a few companies providing the same services. However, the supplier has acquired very varied competences and experience on the customer's projects.	There are a few companies providing the same services. However, the supplier has long experience on the customer's projects, and most of its staff have worked for the customer in the past.	Test equipment development is unique in this context, but there is another company that could possibly replace the incumbent supplier.	There are a few companies providing the same services. However, the supplier has special competences in certain areas that might be difficult to replace.	It would be very difficult to find another company to replace the supplier, owing to its special competences and experience in a specific technology area.	There are several companies providing the same services. However, the supplier's long experience with the customer, and prompt supply of prototypes, are benefits.
2. Do the supplier's competences/resources complement the resources of the customer? (i.e., there are no overlaps)	Most of the supplier's competences overlap with those of the customer. The exceptions are in some special areas.	The customer does not have any technical writing competence.	The customer has internal competences, but due to a lack of resources, it cannot replace the supplier.	Some of the supplier's competences overlap with those of the customer. Certain tasks could not be performed by the customer.	Currently the customer could not carry out the tasks allocated to this supplier.	The customer's competences in this area were outsourced to the supplier in the past.
3. Do the supplier's competences/resources correspond to the needs of the customer?	Currently there is no need to extend the competences.	The technical skills and competences of the documentation staff should be improved.	The supplier should allocate more resources to the customer's projects.	There are some development needs, e.g., in testing.	Currently there is no need to extend the competences.	Currently there is no need to extend the competences.
4. Does the supplier have a network that is potentially beneficial to the customer?	The supplier networks with different technology suppliers and universities to obtain new competences.	The supplier has started collaboration with the customer's R&D units globally.	The supplier uses its own subcontracting network on customer projects.	The supplier uses its own subcontracting network on customer projects.	The supplier's own network does not play a notable role in the projects.	The supplier uses its own subcontracting network on customer projects.
POWER						
1. How expensive or difficult would the	Due to overlapping competences, insourcing would not	Insourcing would require several new employees, and	Insourcing would require several new	Insourcing would require several new designers, acquiring new	Insourcing would be very difficult. It would be difficult to	Insourcing would require very large investments in

insourcing of the services provided by the partner be for the customer?	be difficult. However, it would require a considerable amount of new capacity.	investment in new tools and systems for documentation and information design.	designers, and training existing employees.	competences, and training existing employees.	find several new designers with specific competences.	electronics manufacturing.
2. How expensive or difficult would it be to change this supplier?	It would be difficult to find a single company to replace the supplier.	Replacing would probably not be as difficult as insourcing. However, data transfer would be a challenge.	Replacing would probably not be as difficult as insourcing.	Replacing the supplier with a new company would be more difficult than insourcing.	It would be very difficult to find a company to replace the supplier.	There are several other companies that could replace the supplier. However, this would require time and effort.

Appendix 2

Interview questions in the first interview round

A1. Is the availability of relevant resources a central factor when decisions on outsourcing and insourcing of R&D work are being made?

A2. Do you prioritize the partner candidates who can provide the best possible competences and capabilities?

A3. How important is the role of governing costs when decisions on outsourcing and insourcing of R&D work are being made?

A4. When external partners are being selected for R&D projects, do you prioritize those who do not require much supervision?

A5. Do you consider the risk of dependence on an external partner an important consideration when decisions on outsourcing and insourcing of R&D work are being made?

A6. Is it usual to allocate a task to internal R&D work if there is a risk that outsourcing the task would create dependence on an external partner?

A7. Is it policy to maintain several partner relationships providing the same competences in order to avoid dependence on one partner?

A8. Is it policy to conduct the R&D work that is related to the customer's core business internally, and outsource all other tasks?

A9. Do organizational identity and traditions steer the decisions on outsourcing R&D work (e.g., is the key thinking that these are tasks we have always done ourselves)?

A10. Does the personal interest of R&D team members steer decisions on outsourcing R&D work?

Interview questions in case interviews (third interview round)

B1. Are the supplier's competences/resources particularly special and unique in the market?

B2. Do the supplier's competences/resources complement the resources of the customer (i.e., there are no overlaps)?

B3. Do the supplier's competences/resources correspond to the needs of the customer?

B4. Is the strength of the supplier's networking performance important, in that it has a network that is potentially beneficial to the customer?

B5. How are the projects managed on both sides of the relationship?

B6. How is steering and control of daily/weekly work implemented in the relationship between the firms?

B7. How effective are the ways of working and processes in the relationship?

B8. Do you use common IT tools in the relationship, and if so how do they work?

B9. Have the actions been performed as agreed, and have the agreed timetables been followed in the relationship?

B10. Is there a need to control the supplier's deliverables?

B11. How much need is there to steer the supplier's work?

B12. To what extent do you need written agreements in the relationship?

B13. How expensive/difficult would it be for the customer to insource the services/activities currently provided by the partner?

B14. How expensive/difficult would it be for the customer to source the services currently provided by the partner from another provider

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Industry and Innovation, 2016
http://dx.doi.org/10.1080/13662716.2015.1123613

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Joint Learning in Innovative R&D Collaboration

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ABSTRACT The present study analyzes the mechanisms and facilitators behind joint learning in R&D collaborations by way of a qualitative comparative case study analyzing three supplier relationships and three internal R&D partnerships of the focal organization. The results suggest a single joint learning process for internal and external relationships in which the role of the customer and the facilitation of the joint learning process vary depending on the context. Whereas the role of motivation is central for joint learning in the internal relationships, mutual trust is important to the external relationships.

KEY WORDS: Joint learning, R&D, collaboration, innovation

1. Introduction

The role of capabilities, competences and knowledge is central to creating and sustaining competitive advantage for firms, and consequently firms have extended their research and development (R&D) activities beyond organizational boundaries. In the realm where the internal collaboration between a main R&D organization and its contributing R&D subsidiaries can be utilized for innovation (Mudambi, Mudambi, and Navarra 2007; Reilly and Sharkey Scott 2014), the role of external R&D suppliers in the product development and innovation activities of multinationals continues to grow (Johnsen 2009; Quinn 2000; Wagner and Hoegl 2006). Innovative R&D between internal and external units requires continuous adaptation and joint learning, which can be considered to be a relational dynamic capability that enables rapid innovation from globally dispersed sources of invention, innovation and manufacturing capabilities (Davis and Eisenhardt 2011; Huikkola, Ylimäki, and Kohtamäki 2013; Un, Cuervo-Cazurra, and Asakawa 2010).

The existing studies on R&D collaboration have considered the joint development of technological innovations attained by combining knowledge, technologies and other resources across organizational boundaries (Powell, Koput, and Smith-Doerr 1996; Stuart 2000), between supplier and customer (Johnsen 2009; Quinn 2000; Wagner and Hoegl 2006), and also in collaborations between a parent R&D organization and its subsidiaries (Andersson, Forsgren, and Holm 2002; Figueiredo 2010; Reilly and Sharkey

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Scott 2014). However, relational-level phenomena, such as interaction and relational practices between partners have attracted less attention. Recent research has highlighted how the collaborative process, and interactions between partners in particular, has been neglected in the previous research on R&D collaboration (Davis and Eisenhardt 2011, 160–161). Moreover, joint learning between partners in R&D relationships is not a widely researched topic, despite it being an important contributor to creating differential advantages and success in relationships (Davis and Eisenhardt 2011; Dyer and Singh 1998; Kale and Singh 2007; Selnes and Sallis 2003). In R&D interactions, the process of joint learning is particularly important because it involves the exchange of tacit experimental knowledge that is difficult to share, make sense of, or implement (Chang and Gotcher 2007; Huikkola, Ylimäki, and Kohtamäki 2013; Selnes and Sallis 2003), and because joint learning has a clear positive impact on a firm's innovative performance (Duysters and Lokshin 2011; Lin et al. 2012).

The present study addresses the following research question: *Which factors facilitate innovative joint learning in an R&D network featuring internal and external relationships?* To address that question, the current research analyzes networked innovative R&D through joint learning, which is central to the innovation process that takes place in the relationship between the parties (Fang et al. 2011; Hurley and Hult 1998, 44). Using a qualitative case study to analyze a network of R&D relationships, this study contributes to existing R&D collaboration literature, first, by proposing that the roles of dependence, embeddedness and innovation are linked in the joint learning process (Selnes and Sallis 2003). Second, the study contributes to the theory of joint learning by adding findings on the facilitating role of motivation and trust—findings that establish that the role varies depending on whether it occurs in the context of an internal or an external relationship. The study also extends the existing R&D literature, which largely neglects the challenges arising from the coordination of internal and external relationships. The findings can have important managerial implications, given that most multinational technology companies utilize both internal and external partnerships to address innovation tasks, and hence face the challenge of coordinating R&D work between internal and external relationships.

2. Theoretical Background

2.1. R&D Collaboration for Innovation

Taking into account the role of internal and external collaboration in innovative R&D, the present study builds on the intersection of the theory of organizational learning (Kuwada 1998; Selnes and Sallis 2003) and the literature concerned with R&D collaboration with external suppliers (Johnsen 2009; Quinn 2000; Wagner and Hoegl 2006), and with internal subsidiary partners (Andersson, Forsgren, and Holm 2002; Figueiredo 2010; Reilly and Sharkey Scott 2014). R&D collaboration refers to complex services offered and exchanged, including product design, feasibility studies, usability analyses, prototype development and testing, manufacturability analyses and product customization (Huikkola, Ylimäki, and Kohtamäki 2013). The volume of research on this topic has been growing recently, as high-technology companies have increased the use of global R&D collaboration networks as a resource for innovation work. R&D collaboration provides the firm with knowledge, resources and technological capabilities it lacks, thus helping increase the

chance of successful innovative products (Gulati 1998; Nieto and Santamaría 2007; Un, Cuervo-Cazurra, and Asakawa 2010). In developing the necessary technological capabilities, cross-functional teams and routines, knowledge creation and knowledge transfer are important elements (Eisenhardt and Martin 2000, 1108). In particular, innovativeness—defined as the "capacity to introduce some new process, product, or idea in the organization" (Hult, Hurley, and Knight 2004; Hurley and Hult 1998)—is largely dependent on cumulative knowledge, shared experience and learning occurring between R&D collaboration partners (Fang et al. 2011; Hoecht and Trott 2006; Nieto and Santamaría 2007). Consequently, the meaning of collaboration routines that bring new resources and knowledge into the firm from external sources has been extended, because those routines build technological and innovation capabilities, especially in knowledge-intensive high-technology areas (Johnsen 2009; Wagner 2010; Wagner and Hoegl 2006).

2.2. Joint Learning in R&D Collaboration

Organizational learning (Kuwada 1998), has been widely conceptualized as a dynamic capability (Kale and Singh 2009; Teece, Pisano, and Shuen 1997) and an antecedent of innovation (e.g. Fang et al. 2011; Hurley and Hult 1998, 44). Moreover, it has been widely accepted that access to external knowledge through relationships, and especially the joint learning taking place in these relationships is capable of improving the firm's innovative performance and R&D capabilities (Ahuja and Katila 2001; Bäck and Kohtamäki 2015; Brown and Eisenhardt 1997; Duysters and Lokshin 2011; Lin et al. 2012). The present study builds on the work of (Selnes and Sallis 2003), who defined joint learning as a joint activity between the supplier and customer, where the parties (1) share knowledge, (2) jointly make sense of the knowledge and (3) integrate that knowledge into relational memory. Previous research has considered joint learning a relational dynamic capability that provides collaborative advantages for all parties involved in R&D collaboration (Huikkola, Ylimäki, and Kohtamäki 2013).

Knowledge sharing refers to the transfer of knowledge through formal and informal interaction between the parties (Chang and Gotcher 2007; Selnes and Sallis 2003) generated to transfer and absorb new knowledge from external relationships (Corsaro, Cantù, and Tunisini 2012, 780). Information asymmetries caused by inadequate information sharing can generate considerable transaction costs in the relationship (Baldwin 2007; Rindfleisch and Heide 1997; Stump, Athaide, and Joshi 2002). Similarly, opportunistic behavior on the part of any partner tends to undermine information sharing and collective knowledge development in the collaboration (Adler 2001; Katila, Rosenberger, and Eisenhardt 2008; Martinez-Noya, Garcia-Canal, and Guillen 2013). Hence, effective R&D collaboration requires the sharing of tacit R&D knowledge between partners in an open atmosphere (Garvin 1993; Kohtamäki and Bourlakis 2012), in which the role of in-depth interaction (Grönroos and Voima 2013), dialog (Ballantyne, Williams, and Aitken 2011) and learning (Chang and Gotcher 2007; Huikkola, Ylimäki, and Kohtamäki 2013) are central. Effective R&D collaboration is possible in relationships characterized by high embeddedness: a reference to the closeness of the relationship, the intensity of information exchange and the extent to which resources between the parties are interlinked (Andersson, Forsgren, and Holm 2001; Reilly and Sharkey Scott 2014; Yamin and

Andersson 2011). In knowledge-intensive high-technology areas, the firms in embedded R&D relationships are often dependent on their partners' specialized and unique competences and skills, that are accordingly difficult to substitute or imitate (Bäck and Kohtamäki 2015; Gulati and Sytch 2007).

Joint sense-making aims at achieving a common understanding through the social process operating between parties (Weick, Sutcliffe, and Obstfeld 2005) by building consensus through finding an appropriate fit between partners' expectations and capabilities (Chang and Gotcher 2007; Huikkola, Ylimäki, and Kohtamäki 2013). This is often challenging in the relational context, in which physical, psychological and cultural distances between actors can be significant (Huikkola, Ylimäki, and Kohtamäki 2013). Shared experience and accumulated technological knowledge acquired through the relationship are among the primary drivers of R&D outcomes (Verona 1999), and they also predict more efficient and innovative collaboration in future projects (Bäck and Kohtamäki 2015; Sobrero and Roberts 2002; Van Echtelt et al. 2008).

Knowledge integration into relationship-specific memory involves the integration of knowledge into relation-specific memories developed by organizations (Selnes and Sallis 2003). These knowledge-based resources spanning firm boundaries are embedded as interfirm resources (Dyer and Singh 1998), and may be related to relational structures, working procedures, routines, products or services (Johnson, Sohi, and Grewal 2004; Lukas, Hult, and Ferrell 1996; Moorman and Miner 1997). In this paper, the concept is referred to as *knowledge implementation* or *institutionalization* (Crossan, Lane, and White 1999; Kuwada 1998), and it involves the transfer of created, shared, and combined knowledge from individuals so it may be reformulated as organization or relationship-specific property (Lukas, Hult, and Ferrell 1996; Moorman and Miner 1997). This phase is central to the process of joint learning, since relational actors inevitably change, threatening discontinuity in the relationships and jeopardizing relationship-specific tacit knowledge (Fang et al. 2011).

3. Data and Methodology

3.1. Comparative Multiple Case Study

This paper relies on a multiple case study approach and examines three internal (subsidiary) relationships and three external (supplier) relationships maintained by the product development unit of a multinational European corporation that is a global market leader in the area of electrical and electronic devices and systems. While the headquarters of the corporation are located in another European country, the bulk of the R&D in the technology area examined in the current study is undertaken at the focal organization in Finland.

Tables 1 and 2 summarize information on the internal partners (subsidiaries) and external supplier companies referred to in the cases. A comparative multiple case study is a suitable method for examining the mechanisms in relationships based on technology collaboration, particularly in view of the complexity of evolving business relationships and interactions (Beverland and Lindgreen 2010; Dubois and Araujo 2007).

Table 1. Case descriptions for the studied relationships between lead R&D unit and its internal partners (R&D subsidiaries)

	Lead R&D unit (Finland)	India R&D unit	USA R&D unit	China R&D unit
Number of employees in the R&D unit	90	80	36	23
Main products/services	Software and hardware development and productization. Ownership of product portfolio and platform-based global R&D development	Software development and minor hardware development. Some independent development for own products	Embedded software and hardware development. Understanding of local markets and requirements in the USA	Productization, localization, testing and verification. Understanding of local markets and requirements in China
Resource complementary/ overlap		This unit provides the lead R&D unit with capacity in software and hardware development. Currently, the unit carries out relatively simple tasks related to platform development steered by the Lead R&D Unit	This unit undertakes embedded software and hardware development as well as productization for US markets. It possesses special competences in local markets and requirements in the USA. The unit also has special competence on certain solutions and algorithms that serve global R&D development	The relationship and collaboration with the China R&D unit are mainly based on its local business competences (customization and productization of the technologies for Chinese market). The unit contributes to platform-based global R&D development on minor part
Innovativeness of the relationship (as evaluated by customer		R&D staff does not actively make innovative proposals	The R&D staff quite actively discuss different technical solutions and propose new ideas	The R&D staff demonstrates innovativeness in their daily work and also propose new ideas
Responsibility to serve local markets		No	Yes	Yes
Actor's share of total R&D	50%	20%	20%	10%
Duration of the collaboration		12 years	12 years	12 years
Participants in the case interview (Lead R&D unit)	–	Technology Center Manager (Finland)*, R&D Manager, R&D Team Manager, Program Manager, Platform Project Manager		
Participants in the case interviews (Partner)	–	Technology Center Manager (India)*	R&D Manager*	R&D Manager*

*Leader of the R&D unit.

3.2. Data Collection

During the period January 2013–March 2014, researchers met representatives of the focal organization monthly to collect information on its internal R&D activities and supplier involvement strategy. In the course of the meetings, a steering group was formed from among the executives of the focal organization to support the research. This team consisted of the technology center manager (who is the leader of the R&D center in Finland) and four managers responsible for technology platform development, software development, hardware development and supplier relationships. In subsequent meetings, the steering group was extended to include managers responsible for the product portfolio, and relevant research and product development projects.

The data collection procedure is illustrated in Table 3. The intention of the first round was to understand how R&D work was organized and how it was allocated between different internal and external network partners. In the second round, a pilot study on case A was conducted to improve the understanding of the topic, and to develop and validate our interview template intended for use in the case interviews (Yin 1994). The materials collected in the first round led to the development of a semi-structured interview template focusing on relationship development, relationship routines and knowledge transfer. Based on this interview and its analysis, we were able to further develop our interview template. The case interview round involved group interviews in person with the representatives of both sides of each relationship, aligning with the call of Brennan and Turnbull (1999) to involve interviewees from both sides of the relationship to validate the analysis. The interviewees were selected by the steering group based on their

Table 2. Case descriptions for the studied relationships between lead R&D unit and its external partners (R&D suppliers)

	Supplier A	Supplier B	Supplier C
Total revenue	EUR 14 m	EUR 1 m	EUR 1 m
Number of employees	200	16	10
Services/resources provided to customer	Embedded system development, including software and hardware design. Testing services	Hardware development on specific areas and embedded software design	Hardware development projects on specific areas
Resource complementary/ overlap	This relationship concentrates on developing systems critical to the customer's products. Most of the supplier's competences overlap with those of the customer. However, the supplier has acquired very varied competences and experience of the customer's projects. It also provides significant R&D capacity for customer being the biggest supplier with almost 50% share of the customer's R&D purchase budget	This supplier complements the competences of the customer in certain technology areas critical to its current product portfolio. It has special competences in these areas that might be difficult to replace. The relationship is based on prior collaboration between some key members currently working in the case company B, so in reality the history of the relationship is significantly longer	The supplier has concentrated in technology development in a unique technology area, mainly carried out in collaboration with the customer. The customer does not currently have internal competence in this area, despite its importance. It would be difficult to find other suppliers currently possessing these skills or even with the capacity to develop them in the short-term
Innovation performance of the relationship (as evaluated by customer)	Innovations are born in this relationship. The supplier actively proposes new methods and technologies that it identifies from different forums worldwide. It also demos and prototypes the new ideas proactively to the customer. The very close collaboration facilitates innovative thinking in the relationship	The supplier has developed radical new solutions for the customer in certain software projects. However, innovativeness is dependent on the project nature, since in the hardware projects there is not so much room for new ideas, but the supplier does actively propose new ideas in these projects	The supplier is very active in acquiring knowledge on its technology area and sharing it with customer. It develops unique new technology with customer, and actively proposes new methods, technological solutions, and approaches in this context
Supplier's share of customer's R&D purchase budget	45%	18%	7%
Customer's share of supplier's R&D service sales	10–15%	45%	20–30%

(*Continued*)

Table 2. (*Continued*)

	Supplier A	Supplier B	Supplier C
Duration of the collaboration	14 years	4 years	10 years
Participants in the case interview (supplier)	CEO[a] Team Leader	CEO Sales Director Project Manager	CEO Project Manager
Participants in the case interview (customer)	Technology Center Manager R&D Manager	Technology Center Manager R&D Manager (2) Project Manager	Technology Center Manager R&D Manager (2) R&D Team Manager

[a]In the pilot study.

experience of and responsibility for the focal relationship. The interviews lasted between 61 and 250 min, and all were recorded. All the interviewees were key decision-makers in the relationship and were interviewed in groups to encourage them to arrive at a consensus.

3.3. Reliability of the Study

To increase the reliability of the study, the researchers applied a data triangulation technique (Beverland and Lindgreen 2010; Huberman and Miles 1994; Huikkola, Ylimäki, and Kohtamäki 2013) that involved harvesting data from the firms' websites and annual reports, both before and after interviewing the supplier and customer. Because the interview data reflected the interviewees' own views on relationship practices and history, they were interpretative in nature, and accordingly we paid attention to monitoring and discussing these issues during the data collection process by comparing the answers on both sides of the relationship, and asking additional questions: a process suggested by Brennan and Turnbull (1999). The researchers read the transcripts thoroughly several times and cross-checked each other's independent interpretations in both within-case and cross-case analyses (Eisenhardt 1989). Once the analysis of the case interviews was completed, an additional interview round was conducted with the customer's core team, to review, discuss and reflect on the results. In the final interview round, open questions were posed to validate our conclusions. These related to the central themes emerging from the interview data. Finally, a report containing the analysis, results along with the conclusions now reported in this study was reviewed with the core team to validate the data analysis and the quoted material used to support the findings.

4. Results

4.1. Relational Case Description and within-case Analysis

This study consists of six relational cases. Three internal cases represent the relationship between the lead R&D unit located in Finland (the focal organization) and its globally dispersed R&D sub-units located in India, China and the USA. These three sub-units

Table 3. Summary of the interview procedure

	First interview round	Second interview round	Third interview round	Fourth interview round
Goal	To understand the organization of R&D work and how the work is allocated between different parties in the network	To deepen our understanding of the topic and validate the questionnaire	To understand special characteristics of each case relationship	To confirm and further define our conclusions by reviewing and discussing the interview results with customer representatives
Interview type	Group interview for customer executives	A pilot study for case relationship A	Case interviews in each relationship by means of group interviews	Group interview for customer executives
Questionnaire	A draft of semi-structured interview template	The first version of semi-structured interview template	Final version of semi-structured interview template	Open questions related to central themes arising in the interview data
Participants (customer)	Technology Center Manager 3 R&D Managers Head of Product Management Research Manager	Technology Center Manager R&D Manager	See Tables 1 and 2	Technology Center Manager 3 R&D Managers R&D Team Manager Platform Project Manager Program Manager
Participants (external partners)	–	CEO of case company A	See Table 2	–
Participants (internal partners)	–	–	Leader of each R&D subsidiary (see Table 1)	–

are the most important internal R&D partners of the lead unit. The three external cases based on the relationship between the lead unit and its key R&D suppliers operating in Finland were selected owing to their importance to joint R&D efforts, and because the core team considered the collaboration with these suppliers to be the most innovative in nature. The lead unit is responsible for the development of products for global markets, and is therefore the owner of the corporation's product portfolio in its area. Because the product development is based on software and hardware platforms, the lead unit also owns the global R&D platforms in this area.

The relationship between the lead unit and its three internal partners is illustrated in Table 1. The information tabulated shows all three sub-units participate in global R&D work in a different manner, while at the same time, the USA and China units in particular also contribute by serving corporate customers in their local markets. This kind of dual role is typical of subsidiaries of multinationals, which must develop the capability to be competitive in their own market and must also be able to respond to the capability needs of other units of the company (Andersson, Forsgren, and Holm 2002).

The US R&D unit has the strongest set of competences, local knowledge, and experience, which it has accumulated over many years. The accumulated competence, knowledge and experience combine to create a critical resource for the company that enables it to serve the important US markets effectively. At the same time, the US R&D unit is capable of contributing effectively to the global R&D task, especially in terms of some special competences that cannot be sourced from elsewhere in the R&D network. The main capability of the China unit is to serve local markets by customizing and localizing the firm's products based on the global R&D platform. This is important for the firm, because the Chinese market is an emerging one, and is marked by its specific requirements and standards that demand local expertise and language skills. The India unit represents the recent trend of technology offshoring—in the sense of relocating in-house R&D activities to low cost countries (Grimaldi et al. 2010; Lewin, Massini, and Peeters 2009)—and the unit does not possess special competences or experience that differentiate it from the other R&D units in the network. One central reason for this is the fact that the R&D staff in this unit has changed frequently, which limits the accumulation of experience and tacit knowledge and reduces the unit's ability to acquire special competences. Thus, the main goal of the India unit is to serve global, platform-based product development without taking on a significant responsibility for the local markets. In practice, the India unit carries out tasks specified by the lead unit.

Table 2 summarizes the information on the three external suppliers referred to in the cases. The suppliers collaborate with the customer on the development, design and implementation of software and hardware for the customer's R&D platform. They all have considerable experience of collaborating with the customer, and all these relationships have provided opportunities for joint learning and innovation for both parties. In terms of volumes, the relationship with supplier A is particularly significant for the customer, because almost half of the R&D purchase budget is allocated to that particular collaboration. This relationship concentrates on developing systems critical to the customer's products. Long-term collaboration has generated valuable relationship-specific expertise for both partners. Most of the supplier's employees work in the customer's R&D teams, are based on the customer's premises, and report directly to the project management function of the customer firm. By conducting knowledge-intensive hardware system design for the customer, the supplier in relationship B complements the competences of the customer in certain technology areas critical to its current product portfolio. The relationship has lasted four years, but is based on prior collaboration between some key members currently working in case company B. The supplier is relatively small, and collaboration with the customer accounts for almost half of its turnover. In relationship C, the supplier specializes in a relatively unique technology area. The supplier has invested significant amounts of money in technology development in this area, and a major part of that development has been carried out in collaboration with the customer. The customer does not currently have an internal development facility or competences in this area, despite the fact that the area is important to its technology portfolio. It would be difficult to find other suppliers possessing these skills, or even with the capacity to develop them in the short term.

4.2. Cross-case Analysis

This section offers an analysis of the data across all of the cases so as to identify differences and similarities in the data collected from the case-specific interviews. Eisenhardt (1989) argued that cross-case analysis forces researchers to go beyond their initial impressions, thereby increasing the probability of their deriving novel findings from the data. In this cross-case section, joint learning relating to innovative R&D in internal and external relationships is analyzed in terms of knowledge sharing, joint sense-making and knowledge implementation. Figure 1 offers a summary of this analysis.

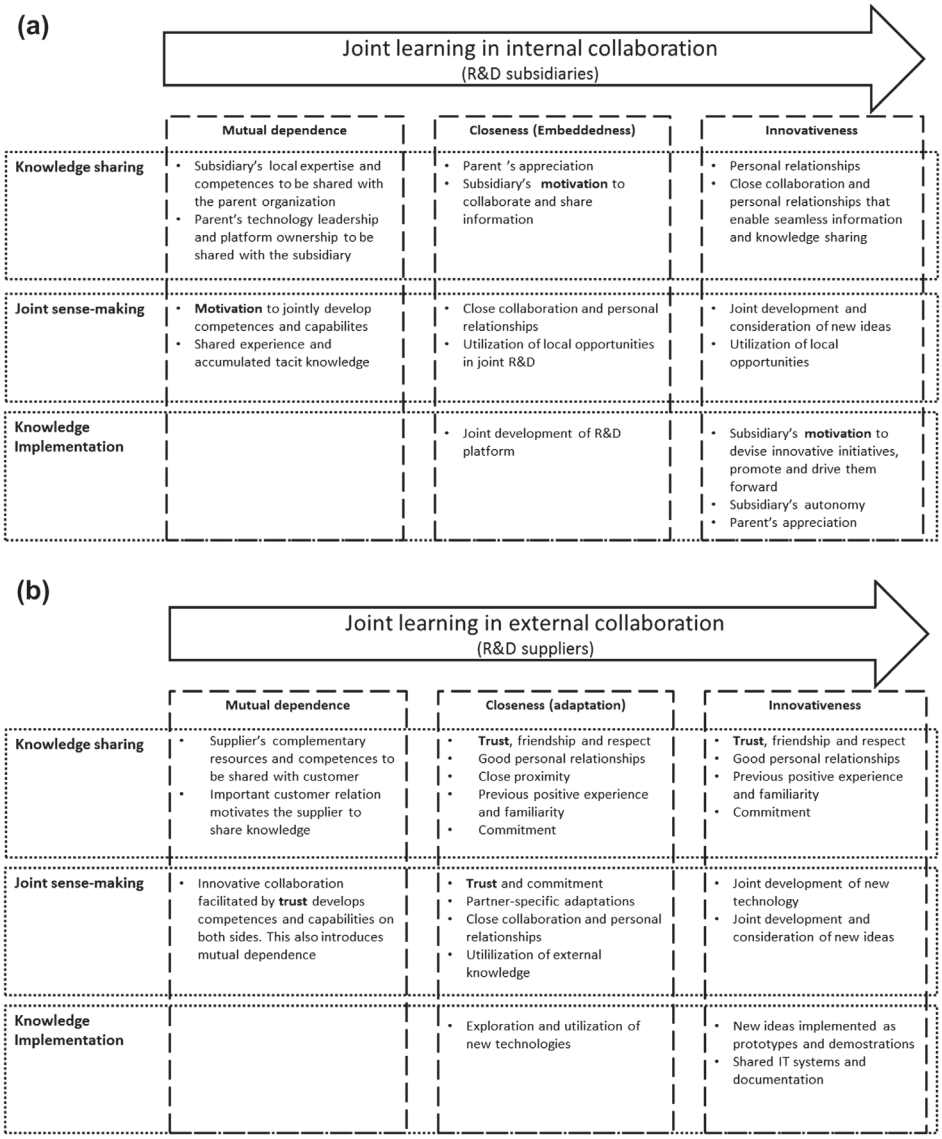

Figure 1. The facilitators of joint learning in the R&D network containing (a) internal and (b) external relations

Knowledge sharing. Tsai (2001, 996) concluded that "knowledge transfer among organizational units provides opportunities for mutual learning and inter-unit cooperation that stimulate the creation of new knowledge and, at the same time, contribute to organizational units' ability to innovate." A significant volume of literature focusing on intra-organizational knowledge flows regards knowledge accessibility as a driver of innovation (Monteiro, Arvidsson, and Birkinshaw 2008; Mudambi, Mudambi, and Navarra 2007; Reilly and Sharkey Scott 2014; Tsai 2001).

> In our R&D projects, we usually consider where we can find the best competence to perform a particular task. Whether this competence is found in our internal team or with a partner, is a side issue. (R&D Manager, Lead R&D center)

For this, cross-functional project teams containing members from all relevant parties are essential (Andersson 2003; Eisenhardt and Martin 2000)

> In the project teams we have members from our internal and external partners involved in the projects. We have regular weekly meetings, in which we go through all the actual issues and make decisions together. (Project Manager, Lead R&D center).

Internal collaboration. Having the option to integrate the capabilities of dispersed subsidiaries is often said to be a special advantage of multinational companies (Andersson 2003; Mcevily and Zaheer 1999; Yamin and Andersson 2011), and integrating technological capabilities and competences developed in subsidiaries is an important task for the lead unit (Birkinshaw and Hood 1998). There is empirical evidence suggesting that it is easier to transfer capabilities and knowledge between a company's internal units than from external organizations (Kogut and Zander 1996). However, a number of scholars have listed barriers to internal knowledge transfer as well (Lane and Lubatkin 1998; Monteiro, Arvidsson, and Birkinshaw 2008; Szulanski 1996). Our case interviews confirm this:

> There are certain challenges in the collaboration with some of our dispersed R&D units. It is sometimes difficult to us to obtain information on the status of their tasks or projects, and they do not always share all the necessary information with us. This can cause delays to our common projects. (Project Manager, Lead R&D Center)

> We feel that the lead unit does not provide us with all the information available on future tasks, for example. I would also like to see more interaction and meetings between project managers and developers in India and the lead center. Currently they meet very seldom. (Technology Center Manager, India R&D Center)

Previous research indicates that knowledge transfer in the network is concentrated with those members who are regarded as capable by the parent organization, whereas the other members are less often involved (Monteiro, Arvidsson, and Birkinshaw 2008). The R&D personnel in those dispersed units are not motivated to collaborate effectively, which in turn reduces the confidence in their capabilities within the parent organization:

> It is sometimes difficult to agree on tasks and time schedules with the India R&D units. Saying "yes" does not necessarily mean a positive answer, and agreed issues must be written down in an e-mail or memo. Otherwise they tend to be forgotten. (Program Manager, Lead R&D Center)

Motivational factors and personal relationships have been identified as a major creator of barriers to information and knowledge transfer between sending and receiving units (Lane and Lubatkin 1998; Monteiro, Arvidsson, and Birkinshaw 2008; Szulanski 1996). This may be the case with the India unit:

> The members of the R&D staff in the India unit change very often. This makes it difficult to establish a personal relationship with them. (Program Manager, Lead R&D Center)

Nevertheless, even if a network is geographically distant, it can be very proximate in terms of expertise, common interfaces and relationships (Mudambi 2011). The USA R&D unit is an example of a subsidiary that collaborates effectively and is very willing to share its knowledge and capabilities with the other R&D centers in the network:

> We have organized the collaboration with the lead R&D center in such a way that in each technology area we have found counterpart persons in our center and in the lead center. They are listed as contact persons for all issues related to technology transfer. This way we have made sure that knowledge transfer is as effective as possible. (R&D Manager, US R&D Center)

External collaboration. Our case interviews indicate that regular face-to-face interaction meetings facilitate efficient information exchange (Rindfleisch and Heide 1997). Joint meetings are easier to arrange with partners operating in close physical proximity to the customer, because close proximity facilitates effective face-to-face contact, and product development meetings that are important for the explication and sharing of tacit knowledge (Huikkola, Ylimäki, and Kohtamäki 2013). Furthermore, establishing a common understanding requires discussion (thus a psychological proximity) (Kogut and Zander 1996):

> Our developers work directly under the customer's project management on the customer's premises. In this kind of setup, information sharing is seamless between us and the customer. (Team leader, Supplier A)

> Close collaboration and face-to-face discussions enable us to develop new technology effectively together. (Project Manager, Supplier C)

> Our long-term partners have valuable experience with our projects. Our employees know the supplier's key staff well, which enables open and free discussion. This makes collaboration easy and effective. (R&D Manager, Customer)

The role of trust and a good personal relationship is also apparent in the knowledge sharing. Relational capital (Kale, Singh, and Perlmutter 2000), which refers to the level

of mutual trust, respect and friendship that arises out of close interaction at the individual level between alliance partners, clearly facilitates information sharing between the partners:

> We trust each other and can freely discuss technological issues without fear that the partner would use this information with third parties. (Project Manager, Lead Technology Center)
>
> The customer has acted fairly, and we have never felt that the special knowledge that we to this relationship, would be used in an inappropriate manner. (CEO, Supplier C)

Joint sense-making. The process of searching for common understanding is called joint sense-making (Weick, Sutcliffe, and Obstfeld 2005), and its central goal in the relational context is to find an appropriate fit between partners' expectations and capabilities (Chang and Gotcher 2007; Huikkola, Ylimäki, and Kohtamäki 2013; Kuwada 1998).

Internal collaboration. Joint sense-making is said to be particularly difficult in the relational context, where physical, psychological and cultural distances between actors are present, and it is necessary to reduce cognitive distance (Fang et al. 2011; Henneberg, Naudé, and Mouzas 2010). As mentioned in the previous section, distances and knowledge transfer barriers may sometimes be greater in internal collaboration than in the external form:

> There are cultural differences between our internal partners. Collaboration with our USA unit is quite straightforward but there are some challenges with the India unit. Regarding our unit in China, the main issue is language. (R&D Manager, Lead R&D center)
>
> Informal discussions usually take place with the USA unit, probably because people know each other. (R&D Team Manager, Lead R&D center)

Previous literature has indicated that the extent of dependency between a subsidiary and its counterparts reflects the relative degree of embeddedness between them (Andersson, Forsgren, and Holm 2001; Reilly and Sharkey Scott 2014; Yamin and Andersson 2011).

> It is true that we are dependent on the capabilities of [internal] partners with whom we actively develop new product together more than those who mostly perform tasks given by us. (R&D Manager, Lead R&D center)
>
> We could carry out all the tasks that are currently assigned to the India unit by ourselves, but it would be much more difficult to develop internal competences to replace the competences currently provided by the USA unit. (Technology Center Manager, Lead R&D center)

The data gathered here is consistent with findings that dependency in the relationship between partners reflects their mutual embeddedness. This is particularly the case with the US unit, with which the collaboration is closest. Furthermore, previous research sug-

gests that embeddedness and the subsidiary's potential to contribute to technological development across internal organizational boundaries are related (Andersson, Forsgren, and Holm 2002; Figueiredo 2010; Reilly and Sharkey Scott 2014; Yamin and Andersson 2011). This study's data are also consistent with that finding, suggesting that the degree of embeddedness reflects the innovativeness in the relationship:

> Our collaboration with the [internal] partners who take responsibility for the critical parts of the R&D projects is of course close, and new ideas are developed together. (Technology Center Manager, Lead R&D center)

> We try to be innovative and really find a way how to implement new ideas to parts of the products. It is not always easy to push new ideas forward in a big company, but close collaboration and person level relationships with the lead unit help us in this. (R&D Manager, USA R&D Center)

A subsidiary's ability and opportunities to leverage local ties and knowledge that are often inaccessible or not apparent to the parent company may influence that subsidiary's capability to innovate and thus strengthen its competitive position (Andersson, Forsgren, and Holm 2001; Cantwell and Mudambi 2005; Figueiredo 2010; Yamin and Andersson 2011)

> Our internal partners' local networks and familiarity with the local business environment is a clear benefit to us, and also has a positive impact on the product development projects that we are running together. (R&D Manager, Lead R&D center)

> Our R&D Center in the USA is a good example of an effective utilization of local opportunities and knowledge in product development. (Technology Center Manager, Lead R&D center)

> It would be very difficult to us to supply anything into the Chinese market without the R&D contribution of our R&D center in China. (R&D Manager, Lead R&D center)

Accordingly, a subsidiary's ability to exploit its local opportunities is an important source of knowledge and innovation for the whole corporation. This has been shown not only to improve innovation capabilities but also to promote a greater degree of novelty in innovations (Nieto and Santamaría 2007)

> We are constantly collaborating with our key partners and customers in the USA to find out their needs and expectations of our products. Through this close collaboration, new ideas often arise and they are further developed with our internal partners. (R&D Manager, USA R&D Center)

> In China, we collect information from the field and try to find out how we can serve our customers in the best possible way now and also in the future. We also try to provide this information to the lead R&D center. (R&D Manager, China R&D Center)

External collaboration. Adaptation ties suppliers more closely to the customer and thereby supports interaction and joint sense-making (Brennan and Turnbull 1999; Walter 2003). Partner-specific adaptations are representative of past events, activities and decisions encapsulating common experiences, and therefore facilitate conducting further business (Walter 2003).

> It is very important to us to maintain long-term relationships with partners who are able to follow our R&D processes, use our R&D tools, and who can adapt to our way of working. (Technology Center Manager, Customer)

The supplier's adaptation to the relationship requires trust in and commitment to the customer, which also has a positive impact on trust in and commitment to the relationship on the customer side (Brennan and Turnbull 1999):

> We have been involved in the customer's projects in this specific area for several years. Hence our employees have a very good insight into the customer's needs, requirements, and way of working. (Project Manager, Supplier B)

Our data support the conclusions drawn by others that experience accumulated in joint projects can result in more efficient collaboration and innovativeness in future projects (Nieto and Santamaría 2007; Ragatz, Handfield, and Scannell 1997; Sobrero and Roberts 2002; Van Echtelt et al. 2008). Experience can therefore also facilitate the supplier's embeddedness in the customer's R&D work.

> Our experience gained on the projects with this customer is as long as our company is old, 14 years. (CEO, Supplier A)

As discussed in the previous section, mutual dependence between partners is relative to the level of embeddedness, which in turn has positive impact on innovation capability in the relationship. Mutual dependence is apparent in all three external cases, particularly in relationships B and C, in which the customer's business constitutes a very significant share of the suppliers' sales, and the customer is dependent on the suppliers' competences:

> We know that the customer is dependent on our special competences, which would be very difficult to replace. However, we are also dependent on the customer because it is our biggest customer and this relationship is therefore extremely important to us. (CEO/Supplier C)

> Our dependence on suppliers B and C is relatively high, mainly because of their competences. On the other hand, the trust level is also high in these long-term relationships. (R&D Manager, Lead R&D Center)

> In the relationship with Supplier C, we are developing a unique technology area together that cannot be found anywhere else. This collaboration is innovative in nature, and develops competences and capabilities on both sides of the relationship. (R&D Team Manager, Lead R&D Center)

Hence, trust is a facilitator of effective cooperative behavior in these relationships (Kale, Singh, and Perlmutter 2000; Kohtamäki, Partanen, and Möller 2013; Selnes and Sallis 2003):

> In this relationship, both sides can rely on each other. (Project Manager/Supplier C)

> The trust level is high on both sides of the relationship. (CEO/Supplier B)

In contrast to the situation with internal collaboration, external relationships are affected by the fear of a partner's opportunistic behavior that may create a need for protection, which in turn reduces the interaction between the partners (Coulter and Coulter 2003; Kale, Singh, and Perlmutter 2000; Selnes and Sallis 2003). However, previous positive experiences and familiarity with the supplier reduce this behavioral uncertainty:

> Our people and the suppliers' staff have been working together for years. They know each other well. (Project Manager/ Lead R&D Center)

> We have good personal contacts with the customer's key developers and managers in our area. (Project Manager / Supplier C)

> Our R&D staff work as the customer's R&D team members. Most of them have been in this position for years. (CEO, Supplier A).

All the supplier relationships examined were innovative, meaning the supplier's absorptive capacity played an important part in those relationships.

> We have invested significant amounts of money to develop new technology that we are providing to our customer. This technology is a unique part of the customer's products nowadays, and joint working with the customer has helped us remarkably in the development of this technology. (CEO, Supplier C)

> Our company actively explores and exploits new technologies and R&D tools from different forums worldwide. We present and demonstrate them to our customers and together consider how we could apply them in the customer's projects. (CEO, Supplier A)

The link reported in the previous section between dependence, embeddedness and innovativeness seems to also be valid in the case of external relationships. However, the facilitating factor in external cases is trust, rather than motivation that was a facilitator in internal cases.

Knowledge implementation. Integration of knowledge in relational structures, working procedures, routines, products or services in relationship-specific memory (Selnes and Sallis 2003) is often referred as knowledge implementation or institutionalization (Crossan, Lane, and White 1999; Kuwada 1998).

Internal collaboration. Collaborative efforts between subsidiaries and their parents or peer subsidiaries contribute significantly to organizational knowledge implementation and

innovation development (Reilly, Scott, and Mangematin 2012). In the context of the cases presented in this paper, the global development of an R&D platform is a common goal for all the R&D centers. This platform can be seen as an example of organization-specific memory (Moorman and Miner 1997):

> We are developing the platform together and all the R&D centers contribute to this work. (Technology Center Manager, Lead R&D center)

> In the platform-based working model, we have to forge much closer collaboration with other R&D units than in previous product-based work. Our development work contributes to the platform that is used in our products globally. (R&D Manager, USA R&D Center)

To fully exploit the opportunities arising from subsidiary innovation, the organization needs the ability to recognize the value of new, external knowledge and then assimilate it as part of an organizational learning process (Cohen et al. 1990; Lane and Lubatkin 1998; Tsai 2001). This ability is referred to as an organization's absorptive capacity (Cohen et al. 1990), and it ensures collaborative efforts between subsidiaries and their parents or peer subsidiaries contribute significantly to organizational innovation (Reilly, Scott, and Mangematin 2012). A central factor in this process is the subsidiary R&D teams' willingness to make innovative proposals and actively promote their ideas in collaboration with other units so they will be tested and implemented:

> There are units that constantly take part in platform development in such a way that they really bring potential ideas for development. It requires, however, an active attitude and willingness to push the idea forward. (R&D Manager, Lead R&D center)

> In the USA R&D center, they are quite eager to propose new ideas. This is good, even though not all the ideas can be implemented. On the other hand, our units in China and India are not as active. They concentrate more on regular routine tasks. It may be a cultural issue, or it is about motivation. (R&D Team Manager, Lead R&D center)

> We usually share new ideas within our teams in China and discuss them locally. However, only a small proportion of them are forwarded to the lead R&D center. (R&D Manager, China R&D Center)

It has been argued in the literature that a subsidiary unit's autonomy to engage in activities outside its formal mandate has a positive impact on its innovative potential (Birkinshaw and Hood 1998; Birkinshaw, Hood, and Young 2005; Monteiro, Arvidsson, and Birkinshaw 2008), as does the level of attention it receives from headquarters (Ambos 2010). The analysis conducted in this study supports these findings, since it seems that the US R&D center is appreciated more than the two other R&D subsidiaries studied. This, in turn, leads to both lead unit and subsidiary being more motivated to collaborate and progress jointly-developed initiatives. On the other hand, the India R&D center seems to have a lower level of motivation.

> We often try to allocate easy and straightforward tasks to the India unit, and carry out the more demanding tasks by ourselves or with other partners. This way, we ensure quality and protect the time schedule of the project. (Platform Project Manager, Lead R&D Center)

> We feel that we could do more challenging tasks than we are doing now. (Technology Center Manager, India R&D Center)

Perhaps for these reasons, it seems that this unit does is not appreciated as much by the parent organization as the other R&D subsidiaries studied, which influences motivation:

> Our ideas are quite seldom taken into account. One reason may be that there is not a clear process how to bring our initiatives forward to the lead R&D center. This affects the team members' willingness to suggest new ideas. (Technology Center Manager, India R&D Center)

On the other hand, partners can improve their joint learning activities in the relationship for example by facilitating information exchange and supporting common learning and the sharing of tacit knowledge (Kale, Singh, and Perlmutter 2000; Selnes and Sallis 2003). This also has a positive impact on motivation:

> We have found that on-site training and visits to other R&D centers are a very good way to improve our technological competence. It also improves our team's motivation and collaboration between units, since this way the key persons can make personal contact with each other. (Technology Center Manager, India R&D center)

External collaboration. Similarly to internal collaboration, the firm must be able to interact and exchange resources and knowledge with its partners when it is collaborating with external suppliers (Van Echtelt et al. 2008; Wagner 2010; Wagner and Hoegl 2006; Walsh 1995). Hence, jointly created and shared knowledge is stored in a relationship-specific memory (Moorman and Miner 1997), exemplified by things like implemented products, software, components and documentation:

> Several new ideas have been implemented as a result of collaboration with these suppliers. (R&D Manager/ Lead R&D Center)

External suppliers have a central role in the development of a common R&D platform owned by the lead R&D center. In the joint R&D projects, prototypes created to test and demonstrate new ideas are important.

> We often build prototypes to present and demonstrate our ideas. This has been a successful way of working, since we have been able to get many of our initiatives implemented as parts of the customer's products in this manner. (CEO, Supplier A)

> A jointly-developed design is usually tested by means of a prototype. (Project Manager, Supplier C)

Relationship-specific memory is critical, especially in external relations where relational actors inevitably change, so affecting the relationship's continuity (Fang et al. 2011). As discussed in the section describing information sharing, tacit knowledge can be transferred and maintained by close proximity and frequent face-to-face contacts. Another important way of maintaining the memory is the use of shared IT systems and documentation, and clearly documented meeting practices can assist too:

> Most of our external partners have access to the relevant IT tools needed in our R&D. This enables efficient co-design and ensures that all the necessary information regarding the designs is saved. (R&D Manager, Customer)

> We always share a meeting memo and status report with the customer. (Project Manager, Supplier)

5. Discussion

5.1. Theoretical Implications

Building on joint learning, this study extends the supplier and subsidiary innovation literature by analyzing internal and external R&D collaboration. This is an important research setting, since in most multinational companies, R&D functions now rely on networks containing both internal and external partnerships, and developing processes for innovative R&D in this kind of network is an essential managerial challenge in the R&D organization. The analysis of six R&D collaboration cases revealed that the factors facilitating innovation through joint learning in internal and external relationships are interrelated but also different to some degree as presented in Figure 1.

The first contribution of the results is to extend the existing literature on the linked role of dependence, embeddedness and innovation. As suggested in the literature on internal and external relations, relational interdependence facilitates embeddedness in both internal partner relations (Andersson, Forsgren, and Holm 2001; Yamin and Andersson 2011) and the external forms (Brennan and Turnbull 1999; Walter 2003). Our data are consistent with those findings and indicates that the main reason for dependence in both types of relationships is partner competence and accumulated experience. Joint learning enables the creation of shared experience and promotes accumulated technological knowledge in the relationship, which in turn is the primary driver of R&D outcomes (Verona 1999), and also predicts more efficient and innovative collaboration in future projects (Sobrero and Roberts 2002; Van Echtelt et al. 2008). This is possible only when the partners are embedded, and this way the data illuminate a link between embeddedness and innovativeness. The link is facilitated by personal relationships enabled by relational embeddedness. Our data are consistent with prior literature in that they suggest that this part of the process is equal in both internal relationships (Andersson, Forsgren, and Holm 2002; Figueiredo 2010; Yamin and Andersson 2011) and external relationships (Nieto and Santamaría 2007; Wagner 2010).

The second main contribution lies in the findings on the facilitating role of motivation and trust in joint learning, which varies between internal and external relationships. In those internal relationships largely lacking market governance, the motivation to contribute becomes critical, as effective R&D work requires active, contributory, and innovative behaviors and high levels of motivation. In contrast, in external relationships, where the market mechanism encourages motivation and contribution, achieving the necessary solid trusting relationship becomes key (Coulter and Coulter 2003; Kale, Singh, and Perlmutter 2000; Selnes and Sallis 2003). Hence, the facilitators of joint learning are different for internal and external relationships, which makes separate coordination mechanisms essential. While internal relationships thrive if the parties are motivated, closeness and the development of trust are central to a productive external relationship. Different coordination mechanisms might present challenges, and differing circumstances require specific types of management and leadership behaviors, which can be difficult to action as partners interpret how others are treated, sometimes neglecting to allow for context. Successful coordination leading to increased adaptation may lead to positive spirals of trust and commitment, which in turn can have a positive impact on innovativeness (Nieto and Santamaría 2007; Wagner 2010), whereas distrust may lead to negative spirals of opportunistic behavior (Ghoshal and Moran 1996).

The third main finding is that different roles assigned by the parent unit to its internal partners have an impact on a partner's willingness to contribute to joint learning, and therefore on the link between dependency, embeddedness and innovativeness presented in this study. Because managerial resources are limited, the parent unit pays more attention to and assigns more resources to those partners it adjudges capable. This, in turn, facilitates embeddedness (Ambos 2010), and those partners judged capable become engaged in the knowledge sharing activities, whereas those subsidiaries considered less capable are to some extent excluded from knowledge sharing (Monteiro, Arvidsson, and Birkinshaw 2008). Any exclusion from knowledge sharing will inevitably affect motivation factors to some extent; for example, the India R&D unit seems to have been assigned a secondary role from the beginning of the collaboration since the main reason to start the collaboration with it appears to have been to acquire competitive advantages arising from lower costs. The data indicate neither party is fully satisfied with the relationship, as the responses refer to issues around motivation, competences, and knowledge transfer. Moreover, mutual dependence in this relationship is weak owing to the fact that the subsidiary, as an offshore unit carrying out routine tasks, does not contribute unique competences or capabilities that could foster dependency. In addition, there is no significant utilization of local opportunities. Consequently, the level of embeddedness in this relationship is also low and any contributions to innovation development are minor. In contrast to the India unit, the US R&D unit has clearly been assigned a primary role in the lead unit's internal partner network. In this relationship, both competences and motivation are at a high level, innovations are developed together, and local expertise makes a significant contribution to the global R&D network. Thus, the parent unit's dependence on the unique competences of the US unit is relatively high. The unit's employees have relatively long experience of local market requirements in the USA and the unit is willing to share its expertise and contribute new knowledge to the global R&D network. Naturally, the parent unit appreciates the contribution of the US R&D unit, which in turn increases the unit's embeddedness and fosters information sharing, which in turn has a positive

impact on innovativeness. Hence, the lead unit prefers to assign more resources and pay more attention to this subsidiary since it plays an important role in the firm's innovation strategy.

5.2. Managerial Implications

Developing innovative R&D in a collaboration network containing both internal and external relationships is a key managerial challenge in most multinational high-technology companies. To effectively develop capabilities in the network and encourage innovative initiatives and processes spanning organizational boundaries, managers should be able to understand the key facilitators of innovation and technological capability development. This study reveals specific factors that affect this development. In high-technology R&D relationships, developing technological capabilities and innovation is based on cumulative knowledge built over many years. This often causes mutual dependence between the partners, which in turn fosters embeddedness in the relationship. However, the enablers for this kind of development are different in internal and external relationships. In the former case, the internal partner's motivation to contribute is partly dependent on the parent organization's attention, and that appreciation plays a key role. In the latter case, companies need to protect themselves from a partner's opportunistic behavior, and consequently mutual trust is a necessary enabler of embeddedness in the relationship, which also controls relational dependence. In networked R&D relationships, trust and motivation can be built by maintaining long-term interactions and relationships at a personal level.

5.3. Limitations and Future Research

As an important managerial challenge in an R&D organization, developing innovativeness in an R&D collaboration network containing both internal and external relationships serves several areas of research. An interesting topic for further research would be to investigate the recent trend of R&D offshoring. Building technological and innovation capabilities in the relationships with these new offshore units could be interesting, and a valid topic for further research. Furthermore, the role of motivation, competences, and capabilities in innovative collaboration with these units and other R&D subsidiaries should be studied as well. In addition, quantitative research on innovative practices in internal and external R&D collaboration could be used to verify and further develop the process presented in this paper.

Acknowledgments

This paper is a product of FUTIS (Future Industrial Services) research project. The financial support of the Finnish Funding Agency for Technology and Innovation (Tekes), Fimecc and companies involved is gratefully acknowledged.

Disclosure statement

No potential conflict of interest was reported by the authors.

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This paper was presented at The XXVIII ISPIM Innovation Conference – Composing the Innovation Symphony, Austria, Vienna on 18-21 June 2017. The publication is available to ISPIM members at www.ispim.org.

The Relationship between Supplier Resources and Governance Efficiency – The Impact of Learning

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Abstract: Valuable external R&D competences and capabilities complementing the firm's internal product development resources play an important role for technology firms. At the same time, the transactional costs created by the governance of the R&D supplier relationship affect the boundary between customer and supplier. In an effort to advance the understanding of the relationship between resources obtained in collaboration with external R&D suppliers and governing the efficiency of the supplier relationship, this study examines data from 169 customer–supplier relationships in Finland. The results of the paper draw attention to three specific contributions. First, the relationship between resources provided by the relationship and transactional efficiency of collaborative relationships is positive. Second, the present study extends the understanding of the interactions between the resource-based view (RBV) and the transaction cost approach (TCA) in determining firm boundaries. Third, the study examines how relational joint learning mediates the link between resources and relational transaction efficiency.

Keywords: Supplier involvement; resource-based view; transaction cost analysis; joint learning.

1 Introduction

The fact that high-technology firms outsource elements of their R&D activity to suppliers (Johnsen 2009; Wagner & Hoegl 2006; Quinn 2000) means those firms must determine their organizational boundaries by deciding which tasks, projects, and activities will be undertaken by the organization itself (hierarchical governance) and which will be outsourced to suppliers (market governance). Following the resource-based view (RBV), numerous scholars have advanced the argument that firms' comparative capabilities and competences play an important role in defining the boundaries between customer and supplier (Barney 1999; Jacobides & Hitt 2005; Argyres & Zenger 2012) by maximizing the value of the firm's resource portfolio (Santos & Eisenhardt 2005). Alternatively, a strong research tradition relying on transaction cost analysis (TCA) has argued for the importance of transactional efficiency considerations in boundary decisions (Rindfleisch & Heide 1997). The central argument is that the boundaries should be set at the point that minimizes the cost of governing activities caused by issues such as project management,

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coordination, and monitoring (Santos & Eisenhardt 2005). Capabilities and transaction cost have traditionally been understood as distinct explanations for a boundary choice, and researchers have attempted to validate both the TCA and RBV as single theories to explain boundary decisions in the R&D context (Athaide & Zhang 2011; Eng & Wong 2006; Yasuda 2005; Verona 1999), or have regarded those theories as competing alternatives in attempts to decipher which was best able to explain the boundary choices. However, several scholars have recently scrutinized the interdependences and interplay between boundary explanations (Argyres & Zenger 2012; Santos & Eisenhardt 2005), meaning that exploring relationships among boundary conceptions is now recognized as a new stream of research in the field of organizational boundary theories (Santos & Eisenhardt 2005).

The current research seeks to improve the understanding of the relationship between the resources and knowledge acquired during collaborative projects with R&D suppliers and the governing efficiency of the supplier relationship. In doing so it concentrates on three aspects: The first is that there is a positive association between the resources provided by the collaborative relationship and transactional efficiency collaborative relationships. This is essential in knowledge-intensive relationships between technology partners, in which valuable external resources can complement internal competences and improve performance (Lavie 2006; Eisenhardt & Schoonhoven 1996). The current study also addresses calls in previous research to extend the understanding of the interactions between transaction cost and the capability determinants of firm boundaries (Argyres & Zenger 2012, p.12), which in practical collaboration relationships may coevolve and exert a joint impact (Santos & Eisenhardt 2005). The third aspect the present study examines is how relational joint learning mediates the link between resources and relational transaction efficiency in the relationships between customers and their R&D suppliers. It also facilitates learning about collaboration practices because partners with a shared experience learn to collaborate effectively (Bäck & Kohtamäki 2015, p.24). In summary, this study considers how a partner's resources and competences affect the efficiency of relational governance and also examines the mediating role of joint learning in the R&D supplier–customer relationship.

2 Theoretical background

Resources

The RBV suggests that to maintain their competitive performance, firms must identify external resources and processes that can be employed and combined with their internal resources (Santos & Eisenhardt 2005; Eisenhardt & Schoonhoven 1996). Because the resources owned by different firms are heterogeneous and imperfectly mobile (Lavie 2006; Eisenhardt & Schoonhoven 1996), firms need to seek resources that can complement their own internal resources, which often means using external R&D capabilities provided by partner suppliers. In R&D partnerships, the supplier complements the customer's resources with its specialized and unique competences and capabilities that are usually difficult to substitute or imitate, but which are critical to the customer's R&D performance and competitiveness (Bäck & Kohtamäki 2015). In addition to technical capabilities, accumulated technological knowledge is an important driver of product development outcomes in collaboration (Verona 1999). Research suggests that these complementary resources are particularly important for the success of the relationship (Wittmann et al. 2009; Lambe et al. 2002), since the partners can together

produce outcomes that are superior to those that the customer could produce acting alone. The existing internal resources that partners contribute to the relationship can also be complemented with unique new resources. These idiosyncratic resources are 1) developed during the life of the relationship, 2) created by combining the respective resources of partners and 3) unique to the relationship (Lambe et al. 2002). However, combining firm-specific R&D knowledge into idiosyncratic resources in the relationship is a challenging task, because such knowledge is often tacit and unique in nature, and has been developed in the course of joint activities and within a learning process involving partners (Teece et al. 1997).

Joint learning

A firm collaborating with external R&D partners can obtain the knowledge, resources, and capabilities it needs, and increase its chances of successfully creating new products (Nieto & Santamaría 2007; Kale & Singh 2007). Joint development of competences and capabilities in the relationship can be seen as a process of organizational learning that is widely conceptualized as a dynamic capability in the relationship (Kale & Singh 2007; Teece et al. 1997; Huikkola et al. 2013). The present study builds on the work of Selnes and Sallis (2003) who defined relational joint learning as a joint activity between the supplier and customer, where the parties 1) share knowledge, 2) jointly make sense of the knowledge, and 3) integrate that knowledge into relational memory. It is widely accepted that the relational joint learning arising in an R&D partnership can improve a firm's product development and innovation capabilities and also its performance (Ahuja & Katila 2001; Duysters & Lokshin 2011; Li et al. 2012). The first part of joint learning, knowledge sharing, refers to formal and informal interactions to transfer knowledge between partners (Chang & Gotcher 2007). Knowledge transfer from external relationships provides the partners with access to new and valuable knowledge that can be absorbed to support innovative R&D (Corsaro et al. 2012, p.780). The second part, joint sense-making, refers to the aim of establishing a common understanding through the social process operating between partners. The partners build a consensus by seeking an appropriate fit between their expectations, resources and capabilities (Chang & Gotcher 2007; Huikkola et al. 2013; Bäck & Kohtamäki 2016). The third part, knowledge integration into relationship-specific memory, refers to the integration of jointly-developed knowledge, skills, and competences into relation-specific memories developed and maintained by the partners (Selnes & Sallis 2003; Fang et al. 2011). This part is sometimes referred to as knowledge implementation or institutionalization (Crossan et al. 1999) since it involves individuals transferring jointly created or shared tacit knowledge, skills, or competences between themselves so it can be reformulated as organization- or relationship-specific property (Fang et al. 2011). An example of knowledge implementation would be a prototype developed following a jointly-developed technological innovation (Bäck & Kohtamäki 2016).

Transactional efficiency

The efficiency conception for organizational boundaries (Argyres & Zenger 2012; Rindfleisch & Heide 1997) is based on the theory of TCA. Transaction cost includes the costs arising from relationship coordination, management, and environmental and behavioural uncertainty (Santos & Eisenhardt 2005; Rindfleisch & Heide 1997). In R&D work in particular, specific challenges are related to information asymmetry—the valuation of the input and output of R&D collaboration and the resulting challenges to negotiations and monitoring that both increase transaction costs. Joint action (Joshi & Stump 1999) is a governance mode in which both customer and supplier collaborate in

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the activities that are important for both parties and thus aim to improve transactional efficiency in their relationship. Typical mechanisms applied to manage governance and information issues in joint action in the firm relationship include monitoring and meeting practices between partners, and the selection of proper processes and agreements for the relationship (Rindfleisch & Heide 1997; Joshi & Stump 1999).

3 Research model and hypotheses

The current research proposes a research model to establish a direct link between the extent of resources and the transactional efficiency of the relationship between supplier and customer. This is presented as Hypothesis 1 in Figure 1. It is also suggested that joint learning has a positive mediating effect on the relationship between resources and transactional efficiency (Hypothesis 2). In addition, the model controls for other factors and the research also offers a detailed justification of the model and the hypotheses proposed.

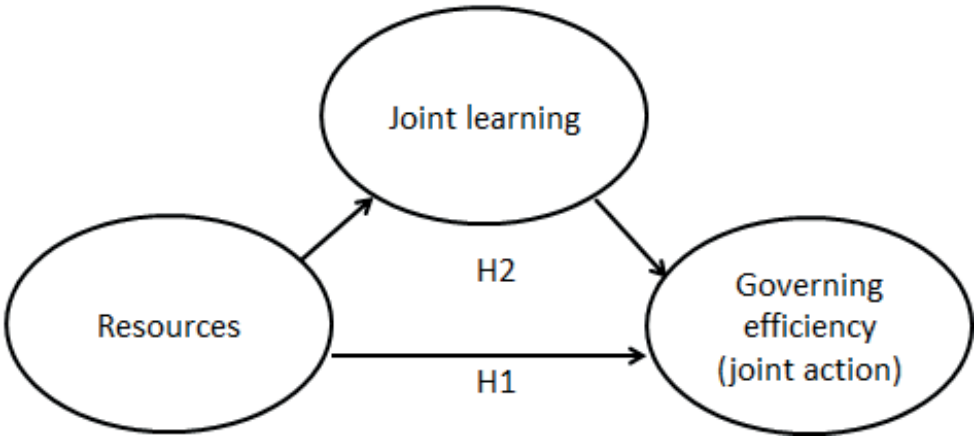

Figure 1 Research model.

The direct impact of a supplier's resources on transactional efficiency

Previous research on R&D relationships suggests that a partner's knowledge, previous experience, and tacit knowledge accumulated in past projects can foster efficient future collaboration (Nieto & Santamaría 2007; Bäck & Kohtamäki 2015) and also ensure the supplier becomes engaged in the customer's product development. Thus, a partner's experience and knowledge affect the efficiency of the relationship and the costs arising from the governance of it (Rindfleisch & Heide 1997), since partners sharing experiences also learn to collaborate effectively (Verona 1999; Bäck & Kohtamäki 2015). Valuable supplier resources also facilitate mutual commitment to the relationship; a commitment that supports the supplier working to adapt to the customer's processes and practices. This adaptation also increases the relational capital that is a main driver of mutual trust in the relationship (Selnes & Sallis 2003; Kale & Singh 2007). A high level of trust in the relationship can reduce the governance costs of the partners' joint projects (Dyer & Chu 2003). Thus, we present the following hypothesis:

> *Hypothesis 1. Supplier relationships incorporating valuable resources will have a positive impact on the relational efficiency within the relationship.*

The influence of joint learning on relational governance efficiency

Joint learning in the relationship can foster the creation of shared experience and unique relationship-specific competences. It also encourages the partners to focus on accumulating experience-based technological knowledge, which in turn is the primary driver of R&D outcomes and effective collaboration (Verona 1999; van Echtelt et al. 2008). Relationship-specific communication and coordination routines also develop over time (Bäck & Kohtamäki 2016), and the partners gradually commit to collaborating and to sharing information (Chang & Gotcher 2007). In addition, a common language is developed for discussing technical and design issues through multiple interactions, which facilitates joint learning through information sharing and joint sense-making (Selnes & Sallis 2003). Accordingly, we propose that joint learning mediates the relationship between resources and efficiency (H1). The learning occurring in an external relationship can further boost competence development within the relationship (Selnes & Sallis 2003; Parmigiani & Mitchell 2009; Kale & Singh 2007). Just as shared experience and accumulated technological knowledge facilitate efficient R&D collaboration, mutual trust and commitment strengthen the relationship between the competences developed through joint learning and efficiency.

> *Hypothesis 2. Joint learning will positively mediate the link between valuable resources and the relational efficiency within the customer relationship.*

4 Methods

To test the hypotheses stated above, the study collected data from the machine and equipment manufacturing industry (SIC 28) in Finland. This original data set contains 186 companies. The survey data were collected May–October 2015.

Data collection

The research relied on an internet hosted questionnaire to gather relevant data. Before distributing the questionnaire, researchers made more than 1500 phone calls to selected firms to identify the respondents with the most extensive knowledge of their firm's R&D supplier relationships and to encourage them to participate. The process led to 334 respondents being sent the link to the survey instrument and was complemented with two reminders. The majority of the identified respondents were R&D managers of their firms (68%), while a quarter (25%) were managing directors, 5% operational or production managers, and 2% were unclassified. The researchers eventually received 186 responses, from which 17 incomplete questionnaires were excluded. The final data set therefore comprises 169 firm cases, a response rate of 50.6%, which can be considered satisfactory in management surveys (Baruch 1999). The respondents accessed were asked to identify the R&D supplier relationship that was the most important for their company's R&D function and then asked questions so that the relationship might be evaluated. Researchers controlled for non-response bias by comparing key variables of those firms responding earliest to a sample of those firms responding latest. Furthermore, there was no evidence of significant differences in variables such as the number of employees, suggesting non-response bias is unlikely to have significantly affected the results.

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Measure development

The constructs used in this study were first verified by applying structural equation modelling (SEM). Subsequently, both the proposed research model and possible non-linear relationships were tested using the Stata 14 program. The measures used in this study were adapted from prior studies and they are reported in Table 1. To confirm translation equivalence, another researcher translated and back-translated the measures used (English-Finnish-English). Moreover, ten R&D managers evaluated the questionnaire prior to data collection and gave feedback on its applicability to gather the targeted information. All items were measured using a 7-point scale anchored with *strongly disagree* (1) and *strongly agree* (7). Building on the work of previous scholars (Wittmann et al. 2009; Lambe et al. 2002), the measurement of resources was undertaken by means of eight items, five representing idiosyncratic resources and three representing complementary resources. Governance efficiency was measured using six items representing joint action (Joshi & Stump 1999). Relationship learning was measured as a multi-dimensional construct containing three sub-dimensions: knowledge sharing, joint sense-making, and integration into relationship-specific memory, which were adopted from Selnes and Sallis (2003). These three theoretical dimensions were averaged into three parcels as presented in Kohtamäki and Partanen 2016. The items loaded above 0.40 onto their main factors without significant side loadings. Moreover, all the factors exhibited Cronbach's alpha values of above 0.7 that can be considered satisfactory. The model fit was analysed using SEM analysis, which indicated high construct validity ($\chi 2$=101.54, RMSEA = .060, CFI = .97, TLI = .96) (Hu & Bentler 1999), and the item loadings were statistically significant ($p \leq 0.001$. Three control variables were included in this study: (1) *Size of the supplier*: Several studies have indicated that firm size may have an impact on learning and knowledge transfer. The firm size was measured using the number of employees (Chang & Gotcher 2007); (2) *The length of the supplier–customer relationship*: The duration of the relationship might relate to the accumulated knowledge and the partners' degree of adaptation in the relationship (Verona 1999). (3) *The physical distance between supplier and customer premises*: A customer firm being in close proximity to its supplier can increase the interaction between the two firms and thus improve the relationship (Bäck & Kohtamäki 2015) and foster more efficient knowledge sharing (Huikkola et al. 2013).

Table 1 Constructs and items.

Constructs and items	*Loading*
RESOURCES (Wittmann et al. 2009; Lambe et al. 2002)	
Idiosyncratic resources CA:.89	
Together we have invested a great deal in building up our joint business	.81
Both of us have made a great deal of investment in this relationship	.87
If either company were to switch to another partner, we would lose a lot of investment made in the present relationship.	.78
Together we have developed a lot of knowledge that is tailored to our relationship	.73
Both of us have created capabilities that are unique to this alliance.	.80
Complementary resources CA:. 83	
We both contribute different resources to the relationship and that helps us achieve mutual goals	.46
We have complementary strengths that are useful to the relationship	.53
We each have separate abilities that when combined enable us to achieve goals beyond our individual reach	.54

JOINT LEARNING (Selnes & Sallis 2003; Chang & Gotcher 2007; Kohtamäki & Partanen 2016)	
Information sharing CA: .86	
Our companies exchange information related to changes in end-user needs, preferences and behaviour	.82
Our companies exchange information related to changes in market structure, such as mergers, acquisitions, or partnering	.65
Our companies exchange information related to changes in the technology of the focal products.	.74
In the relationship, we frequently adjust our common understanding of end-user needs, preferences, and behaviour	.81
In the relationship, we frequently adjust our common understanding of trends in technology related to our business	.71
Joint sense-making CA: .80	
It is common to establish joint teams to solve operational problems in the relationship	.87
It is common to establish joint teams to analyse and discuss strategic issues	.81
The atmosphere in the relationship stimulates productive discussion encompassing a variety of opinions	.58
Integration into relationship-specific memory CA:.74	
In the relationship, we frequently evaluate and, if necessary, adjust our routines in order-delivery processes	.69
We frequently evaluate and, if necessary, update the formal contracts in our relationship	.49
We frequently evaluate and, if necessary, update information about the relationship stored in our electronic databases	1.00
TRANSACTIONAL EFFICIENCY (Joshi & Stump 1999)	
Joint action CA .83;	
We work jointly with this supplier on all product modification issues that may have an effect on both partners	.42
We work jointly with this supplier on all cost-cutting issues	.45
Our long-range plans are formed jointly with this supplier	.76
We have developed a work environment wherein both companies feel part of each other's organization	.80
We work jointly with the customer in training our people to understand our needs better	.78
Control variables	
Size of the supplier	
Length of the customer–supplier relationship	
Distance in terms of travelling time	

Table 2 Correlation among constructs and control variables.

	1.	*2.*	*3.*	*4.*	*5.*	*6.*
1. Resources	1.00					
2. Joint action	.615**	1.00				
3. Joint learning	.624**	.789**	1.00			
4. Size of the supplier	.086	-.048	.024	1.00		
5. Length of the relationship	.070	-.042	.018	.085	1.00	
6. Distance (travelling time)	-.070	.019	-.099	.018	-.092	1.00

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Table 3 The results of ordinary least squares regression analysis and hypothesis tests.

Hypothesis	Model 1	Model 2	Model 3	Model 4
Dependent variable	Efficiency (joint action)			Joint learning
Controlled effects				
Size of the supplier	.000(-.51)	.000(-1.40)	-.000(-.04)	-.000 (-1.11)
Length of the customer–supplier relationship	.002(-.41)	-.001(-1.04)	-.002(-1.74)	-.000(-.15)
Distance in terms of travelling time	.003(.19)	.010(.85)	.016(1.95)	-.001(.-.87)
Main effects				
Resources		.692(9.05) **	.236(3.20) **	.657(8.84) **
Joint learning			.655(9.88) **	
R2	.004	.399	.663	.390
Adjusted R2	-.020	.379	.649	.371
F	.17	20.70	48.87	20.16

5 Results

The highest correlation between independent variables is .789 (see Table 2), which is that between joint action and joint learning. The other independent variables seem to correlate moderately. The researchers tested for multicollinearity using the variance inflation factor (VIF), which was well below 2.0 for the independent variables, against the suggested multicollinearity threshold of 10.

The hypotheses presented in this study were tested by performing ordinary least squares regression analysis. The standardized coefficients and associated *t*-statistics for independent variables in terms of the five tested models are reproduced in Table 3. The research team utilized the Stata 14 software program and the adoption of mean-centred constructs to test the study's hypotheses. Model 1 in Table 3 tests the effects of the control variables on governance efficiency. According to Baron and Kenny (1986), three conditions are mandatory for a variable to be considered a mediator. Testing the first condition (Model 2) made it apparent that resources have a significant and positive effect on governance efficiency ($b = .692$, $t = 9.05$, $p < .001$), which supports Hypothesis 1. As the second condition, Model 4 tests the effect of resources on the mediator (joint learning), this relationship was also found to be significant and positive ($b = .657$, $t = 8.84$, $p < .001$). As the third condition, the effect of both resources and joint learning on the efficiency of governance was tested. Applying Model 3 greatly reduced the previously presented path between resources and governance efficiency (Model 2) ($b = .236$, $t = 3.20$, $p < .001$), whereas the effect between joint learning and governance efficiency became higher ($b = .655$, $t = 9.88$, $p < .001$). This analysis suggests that joint learning mediates the association between resources and governance efficiency represented by joint action, thus supporting Hypothesis 2.

6 Discussion

Theoretical implications

This study presents three main contributions to the literature on organizational boundaries in R&D collaboration between suppliers and customers. First, this study is one of the few to provide empirical evidence of the positive effect of resources provided by a partnership between a customer and its R&D supplier on the governance efficiency of the relationship. The RBV suggests that when an organization's own internal resources are extended by environmental opportunities provided by external actors, competitive advantage can accrue (Lavie 2006). The specialized and unique competences, experience, and knowledge provided by external R&D suppliers are typically difficult to substitute or imitate, but they are often critical to the customer's R&D outcomes, innovation performance, and competitiveness. These kinds of valuable external resources, and especially the competence and tacit technological knowledge that accumulates in the relationship during the collaboration, can also foster more efficient interaction and joint action on future projects (Verona 1999), since partners learn to collaborate efficiently through shared experience (Bäck & Kohtamäki 2015). The shared experience and jointly accumulated tacit and unique relationship-specific knowledge facilitate the development of idiosyncratic resources within the relationship (Lambe et al. 2002). Second, this study contributes to the calls for further research on the interactions between organizational boundary theories by investigating the relationship between resources and efficiency. The study offers evidence of the mutual relationships of these two theories in the context of collaborative R&D relationships between firms. Third, the present study shows that joint learning mediates the link between resources and relational transaction efficiency in supplier–customer relationships. Relational joint learning is a phenomenon essential to knowledge-intensive R&D collaboration because it also involves the development of joint experience, which in turn extends the familiarity between the players on both sides of the relationship. Thus, the relational actors learn to collaborate efficiently, which facilitates more efficient governance of joint development projects (Bäck & Kohtamäki 2015; Huikkola et al. 2013).

Practical implications

Managing a product development network incorporating both internal technological capabilities and resources contributed by external R&D suppliers is a considerable managerial challenge. That is especially the case for those responsible for R&D supplier relationships in high-technology firms who must decide which projects and tasks will be undertaken internally and which are to be outsourced to R&D suppliers. R&D managers have to decide on the use of external resources, which may include complementary competences and capabilities, and which may in turn introduce competitive advantage through improved innovation performance or timing, but must at the same time control the governance costs of external R&D relationships arising from project monitoring, agreements, and supplier steering. This study reveals that the use of valuable external resources that are both complementary and idiosyncratic means the governing efficiency of the relationship can also be high. The current research also highlights the meaning of relational joint learning, which facilitates the joint development of competences and capabilities in the relationship. Besides developing valuable technological competences, joint learning also extends the partners' learning on the subject of project practicalities

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and joint processes, which in turn have positive impacts on the efficiency of the governance of their relationship.

Acknowledgement

This paper emerges from the research project FIMECC S4Fleet. The financial support of the Finnish Funding Agency for Technology and Innovation is gratefully acknowledged.

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Technology Innovation Management Review March 2017 (Volume 7, Issue 3)

A Managerial Decision Tool for R&D Outsourcing and Partner Selection in High-Technology Industries

Iivari Kunttu

> *"Our own R&D relies quite heavily on long-term relationships with competent R&D suppliers. However, we have noticed that we tend to continue our outsourcing activities without regular reconsideration even if it would perhaps be more feasible to carry out some outsourced tasks internally. In a similar manner, performing some tasks that we have always done internally might be more efficient if we outsourced them. Therefore, we have realized it is important to consider our R&D outsourcing and insourcing practices based on rational reasoning."*
>
> R&D Manager (Interviewee in this study)

Deciding which tasks and projects are best performed in-house and which should be outsourced to external suppliers are, alongside the supplier selection process, among the key challenges for R&D managers operating in high-technology firms. This study presents a decision tool for evaluating whether to pursue R&D tasks in-house or to outsource them. The tool also helps R&D managers to evaluate which of the supplier candidates would be best suited to undertake the task to be outsourced. The tool is based on four views of evaluation that both managerial and theoretical roots: identity, dependence, efficiency, and competence. The tool has been developed in a qualitative multiple case study based on R&D supplier relationships and has been empirically tested in an R&D organization.

Introduction

High-technology firms now recognize that strategic investments in collaborations with external R&D partners are critical to developing successful product innovations. However, the challenges of this approach require companies to enhance and reorganize their R&D capabilities to access competencies and resources from external R&D suppliers through outsourcing (Geringer, 1991). Accordingly, suppliers of R&D functionality have an increasingly important role in product development and innovation (Johnsen, 2009; Quinn, 2000; Wagner & Hoegl, 2006). For this reason, it is essential for companies to understand which kinds of external partners are best suited to R&D alliances (Paananen, 2012) and how the tasks and projects suitable for outsourcing should be selected (Geringer, 1991) . Similarly, it is important for the effective implementation of R&D in the dynamic environment of high-technology industries that managers understand which resources are necessary in their organization and which resources can be outsourced to complement internal resources, improve R&D performance, or to split costs and risk (Eisenhardt & Schoonhoven, 1996; Verona, 1999).

R&D managers must regularly decide how best to utilize an external supplier's resources and simultaneously deploy and develop their firm's own internal R&D resources. To serve this end, there are several approaches to facilitate the decision making concerning outsourcing decisions. Literature on organizational boundaries (Santos & Eisenhardt, 2005) presents four conceptions – efficiency, competence, dependence, and organizational identity – all of which have a solid theoretical background and are applied in industry.

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The *efficiency* conception considers the governance costs that the collaboration with external suppliers creates for the customer organization. According to this conception, an activity should be outsourced if the external supplier's production costs and the relationship governance costs together are less than the customer's internal production costs (Dyer, 1996; Rindfleisch & Heide, 1997). This kind of decision making has been a popular choice, especially in those industries characterized by intense price competition and a stable structure (Santos & Eisenhardt, 2005). However, in the dynamic environments of high-technology industries, market requirements, competition, and speed of technology renewal (Heide & Weiss, 1995) create a constant need for developing and sustaining product innovation capabilities, and therefore, capabilities provided by external partnerships steer the outsourcing decision more than the direct and indirect costs of the partnerships.

The *competence* conception emphasizes the value of knowledge resources, special competences (Lambe et al., 2002; Wittmann et al., 2009), and dynamic capabilities (Teece et al., 1997) provided by external R&D suppliers. Therefore, under this conception, outsourcing and partner selection decisions are based on valuable and unique competences provided by suppliers. However, when making decisions concerning outsourcing, managers also have to consider how dependent the customer will become on the supplier's specialist competences and capabilities that may be difficult to substitute or imitate (Gulati & Sytch, 2007).

According to the *dependence* conception, the risk of high dependence on external partners in strategically important technology areas may make the customer vulnerable to a supplier's opportunistic behaviour: a vulnerability that may cause the customer to favour performing those activities in-house (Mayer & Nickerson, 2005). Therefore, power-based decisions aim to control the dependence on external supplier partners by retaining crucial projects in-house and outsourcing activities that will not cause dependence on single suppliers.

The fourth conception, *organizational identity* (Weick et al., 2005), is based on managerial experience, personal views and attitudes, as well as organizational traditions (Santos & Eisenhardt, 2005). Identity-based decisions are usually based on prior experience of supplier collaboration, and therefore, identity-based outsourcing decisions often favour continuation of outsourcing practices with trusted, familiar suppliers. Thus, identity-based decision making often lacks a systematic process to support rational reasoning (Bäck & Kohtamäki, 2015).

A recent study on R&D outsourcing decision making (Bäck & Kohtamäki, 2015) reveals a central problem: R&D managers may either make decisions based on experience- and identity-based reasoning, or alternatively, they may focus solely on one rational viewpoint such as governance cost or supplier competences. Therefore, Bäck and Kohtamäki (2015) suggest that managers should consider a wider range of factors, including the dependence, efficiency, and competence viewpoints, to facilitate rational and systematic decision making when evaluating outsourcing and insourcing activities. Accordingly, the present study presents a practical decision-making tool based on the four abovementioned conceptions of R&D measurement to support outsourcing decisions. The tool is designed primarily for two purposes: i) to help managers decide whether or not a particular piece of development work (task) is suitable to be outsourced to an external technology partner (supplier) and ii) to help them decide which of the known supplier candidates is best suited to perform the task. Therefore, the tool is primarily designed to support decisions concerning supplier involvement in the R&D function, not research or innovation collaboration that usually emphasizes joint knowledge creation and learning with research partners (Bäck & Kohtamäki, 2016; Laursen & Salter, 2006).

Background

From organizational identity to strategy-based decision making

As described in the introduction, the view of organizational identity is based on the observation that managerial cognition and managers' personal experiences, views, and attitudes, alongside an organization's traditions, tend to dominate other rationally grounded reasons when technology firms make decisions on R&D outsourcing or insourcing. The combination tends to promote those decisions that are aligned with the current, tradition-based identity (Brown & Starkey, 2000; Santos & Eisenhardt, 2005). Therefore, when a firm has a strong organizational identity, it can dominate to the extent that the firm will only act in a way consistent with its existing identity, and it can mean that its decision making is not always entirely rational (Brown & Starkey, 2000; Santos & Eisenhardt, 2005). Accordingly, identity often affects decisions on R&D outsourcing because any decision that might challenge the traditional way of working is not easily accepted in an organization, even if there is clear evidence of improved performance, efficiency, or better technological capabilities, for example (Santos & Eisenhardt, 2005). One way to overcome this limitation would be to en-

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courage a clear R&D strategy that could steer identity-based decisions by defining the core competence areas and core business in which the internal R&D function wants to be involved (Bäck & Kohtamäki, 2015). Thus, an organization should devote effort to determining the valuable competence areas it wants to own and develop, and also to deciding upon the areas that can be outsourced. Doing so would permit such an organization to define its identity through a consensual strategy that facilitates systematic and rational decision making.

Dependence on suppliers

In networked, knowledge-intensive technologies, firms may be dependent on the special competences, resources, and skills provided by their suppliers. This is because these resources are typically difficult to substitute or imitate (Gulati & Sytch, 2007) and, consequently, it is expensive and difficult to switch partners (Heide & Weiss, 1995). Accordingly, firms must decide how much dependence on external suppliers they can tolerate to improve their R&D performance (Gulati & Sytch, 2007), or alternatively, they must ensure that their strategically crucial R&D projects are carried out in-house to avoid dependence. Internalizing these projects may, in turn, limit the customer firms' access to the unique competences and skills possessed by their partners (Mayer & Nickerson, 2005). Therefore, when making decisions on outsourcing an R&D project or task, R&D managers must usually consider the extent to which outsourcing would make the customer firm dependent on the supplier. The key factors would relate to the time and cost of switching a partner or bringing the task in-house. The cost of switching partners can be significant if the partnership requires investment or competence development by both parties. In addition, subsequent partner switching would be complicated if the competences of the supplier are very rare and difficult to imitate. For this reason, companies may decide to maintain internal competences in their critical technology areas even as they employ suppliers on tasks in those areas, or they may decide to employ several sources in each technology area. Previous research has shown that customers tend to tolerate dependence on those suppliers with whom they have a long-term and close relationship (Bäck & Kohtamäki, 2015). This is because previous positive experience and familiarity with a supplier serves to increase mutual trust, which in turn tends to increase the tolerance of dependence.

Governance efficiency

When product development projects are outsourced to external partners, the customer firm must take care of the governance of the project and also the relationship with the supplier. R&D project governance costs are transaction costs that arise from the mechanisms related to agreements, project management, information sharing, as well as negotiation, monitoring, and meeting practices with the external partner. These costs can have a significant effect on decisions on whether to outsource R&D work or retain it in-house (Eng & Wong, 2006; Rindfleisch & Heide, 1997). The efficiency of governance can be measured on the basis of the efforts required of R&D managers to manage, control, and steer projects. In this context, successfully adhering to schedules is obviously important, because extending a planned project time also increases the project governance cost. Research has shown that there are several key factors that affect project governance costs. First, previous experience and knowledge accumulated in earlier similar projects are important because experienced teams do not need as much steering and control as teams that are still acquiring competences in the relevant technology. Second, the R&D team's ability to adapt to the established processes of the lead company is also important, because having that ability reduces the need for project monitoring and meetings, and because an R&D supplier must adapt to its customer's internal processes and tools (Gulati & Sytch, 2007; Rindfleisch & Heide, 1997). A willingness and ability to adapt also supports interaction and creates entrance barriers for competing firms (Brennan & Turnbull, 1999; Walter, 2003). Third, the cost of negotiating and drafting contracts is an important factor affecting project governance costs, because long-term relationships with trusted partners typically have less need of written agreements than relationships with new partners would. These are important reasons for organizational decisions affecting make-or-buy decisions in dynamic high-technology environments (Bäck & Kohtamäki, 2015).

Competence

The competence conception is based on the view that competitive advantage flows from processes that enable value creation from resources and competences (Eisenhardt & Schoonhoven, 1996). This value creation has a significant strategic meaning in R&D, where joint learning and the development of technological capabilities and skills facilitate the creation of valuable knowledge in internal R&D and in any collaboration with external suppliers. Having access to the best possible skills and resources to perform each project or task is most important in managerial and organizational decisions, because technological capabilities are usually regarded as primary drivers of R&D outcomes (Verona, 1999; Wagner & Hoegl, 2006). The competences and capabilities of prospective partners are usually the key factors in de-

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cisions on whether to outsource R&D and in any subsequent partner selection process. Other factors in the decision might be the networking performance and networking capabilities of the supplier, because the resources provided by the R&D supplier network can boost the lead firm's competitiveness (Gulati, 1998; Ritter & Gemünden, 2003). In the interactions between the customer firm and its supplier network, joint learning is particularly important because it involves the exchange of tacit, experience-based knowledge that is difficult to transfer (Bäck & Kohtamäki, 2016; Selnes & Sallis, 2003) and because this kind of joint learning has a positive effect on a firm's innovative performance (Duysters & Lokshin, 2011; Lin et al., 2012).

Tool Development

Bäck and Kohtamäki (2015) present example cases of collaborative supplier–customer relationships that were initiated largely on the basis of identity-based decision making, but which over the years of collaboration developed and grew into a form in which they were examined and analyzed in terms of identity, dependence, competence, and efficiency. The primary motivation for developing the R&D outsourcing tool presented in this article is a key conclusion of the work of Bäck and Kohtamäki (2015), which stated that managers' personal views and organizational traditions tend to dominate R&D outsourcing decisions, or alternatively the decisions are made based on a single criterion such as governance cost or competence instead of a broader range of criteria. This conclusion supports the use of objective analysis methods based on rational reasoning in organizational decision making that could challenge accepted practices and conventions.

To develop this tool, the author utilized the interview data obtained in a multiple-case study that examined six key R&D supplier relationships of a leading multinational corporation operating in the area of electrical and electronic devices and systems (Bäck & Kohtamäki, 2015). The empirical data collection for the research involved meetings and discussions with senior corporate executives responsible for product development, product management, and research to collect general information on the corporation's R&D activities and supplier involvement strategy. To identify the key factors that affect the outsourcing decisions in the R&D organizations, data on outsourcing decision making were collected in interviews with R&D managers who were each responsible for one of the six collaborative relationships with R&D suppliers. Based on these key factors, which were all related to one of the four conceptions presented earlier in this article, a set of questions concerning the R&D project outsourcing was formulated. These key questions were then reviewed and analyzed with the group of R&D managers participating in the interviews.

The R&D outsourcing decision tool supports make-or-buy decisions in the R&D area. The purpose of the tool is to analyze outsourcing decisions relating to an R&D project or task by using a template comprising two phases as presented in Figure 1. The template presented in Table 1 requires R&D managers to respond to each question related to each conception using a 5-point scale anchored with *strongly agree* (1) and *strongly disagree* (5), and to record their reasons for the decision in a description field. In Phase 1, the effect of an outsourcing decision is analyzed based on questions concerning *strategy* and *dependency*. Questions related to strategy help managers to consider how much the potential outsourcing of the selected task aligns with their firm's R&D strategy. Empirical observations in R&D organizations (Bäck & Kohtamäki, 2015). suggest that, in many cases, managers must first define the strategic goals of their organization before they can be made available to guide strategy-based decisions. At the end of Phase 1, the tool calculates a summary score for both strategy and dependency viewpoints. These scores provide an indication of whether outsourcing would be an appropriate course of action. Phase 2 involves assessing the expected *efficiency* and *competence* of the external supplier candidates against those of the internal R&D function. Again, the tool calculates a summary score for both efficiency and competence, but in this case, the scores are calculated for all supplier candidates and for an internal R&D operation separately. Thus, the user can compare the scores of internal R&D and supplier candidates and use that information as a basis for the outsourcing or insourcing decision.

Conclusion

Managers in high-technology industries decide whether to outsource R&D work based on their previous experience or interpretations of the environment. These interpretations can be influenced by personal, subjective views or by tangible factors. Instead of concentrating only on previous experience or personal opinions, or solely on a prospective partner's efficiency or competence, it would be beneficial for managers responsible for R&D supplier relations to adopt a range of viewpoints to support their decisions. This study presents four theoretically and empirically grounded conceptions – effectiveness, efficiency, competence, and

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dependence – available for use when evaluating the benefits of R&D collaboration with external suppliers. Previous research identified several factors related to those conceptions that affect how firms select their R&D suppliers and how the decisions on outsourcing R&D tasks are being made. Those factors provide the foundation of the practical decision template presented in this study.

The main contribution of this study is to present a tool capable of facilitating the decision-making process related to R&D outsourcing and partner selection. It provides a practical but theoretically grounded way to rapidly evaluate and compare internal R&D capabilities with those available externally. When adopting and using the tool, customer R&D organizations may also need to define and elaborate their R&D strategy by considering their core capabilities and defining general guidelines for outsourcing activities. These activities in turn facilitate the change from identity-based decision making to decision making based on a broadly accepted organizational strategy. Given that the tool has primarily been developed to assist decisions concerning the potential outsourcing of R&D tasks, it is not a primary choice for decisions on innovation or research collaboration aiming for joint learning and knowledge creation. The development of a tool for facilitating partner selection in those cases is a natural subject for further research in this field.

Acknowledgments

This article emerges from the research project FIMECC S4Fleet. The financial support of the Finnish Funding Agency for Technology and Innovation is gratefully acknowledged.

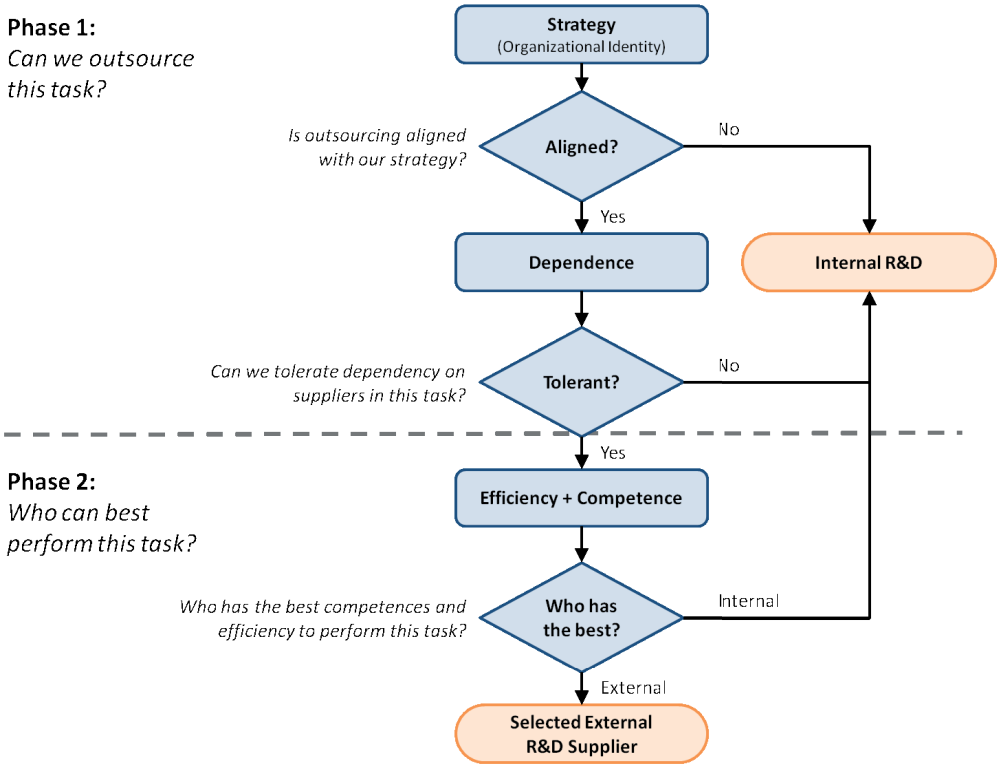

Figure 1. Outline of the R&D outsourcing decision tool

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Table 1. Template of the R&D outsourcing and partner selection decision tool

Phase 1	**Question / Statement**	**Evaluation (1…5)** (1=strongly agree, 5=strongly disagree)	**Comments/Reasons**		
Identity and Strategy	The task belongs to our core business / core competence area.				
	Carrying out this task by ourselves is in line with our R&D strategy.				
	Carrying out this task by ourselves is the best decision from the viewpoint of our organization's operation, competence, and identity.				
	SUMMARY (Average number)		1 suggests outsourcing, 5 suggests insourcing		
Dependence	Outsourcing the task will probably lead to strong dependence on the selected partner.				
	It would be particularly difficult to change the partner afterwards.				
	It would be particularly difficult to insource the task afterwards.				
	We will not maintain replacement partnerships (second sources) or internal competences to limit dependence on the selected partner.				
	SUMMARY (Average number)		1 suggests outsourcing, 5 suggests insourcing		
Phase 2	**Question / Statement**	**Internal R&D (1…5)**	**Supplier 1 (1…5)**	**Supplier 2 (1…5)**	**Supplier 3 (1…5)**
Efficiency	The total cost of the project/task will probably be reasonable when compared to common cost level.				
	Governance and steering costs of the project/task will probably be small (i.e., we do not need to commit much of our own time and resources to project management).				
	Collaboration between project/task stakeholders and communication will probably be easy.				
	It is expected that time schedules and agreements will be adhered to.				
	The need to control the deliverables is minor.				
	SUMMARY (*Average number for each column*) (1 suggests low efficiency, 5 suggests high efficiency)				
Competences and Resources	This party has the best possible competence and resources to carry out the task.				
	This party will commit to developing its competences and capabilities relating to this task.				
	This party has sufficient capacity to carry out the task.				
	Having this party carry out the task provides opportunities for new learning and to deliver innovations.				
	SUMMARY (Average number for each column) (1 suggests low competences, 5 suggests high competences)				

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http://doi.org/10.1016/j.indmarman.2008.02.007

Citation: Kunttu, I. 2017. A Managerial Decision Tool for R&D Outsourcing and Partner Selection in High-Technology Industries. *Technology Innovation Management Review,* 7(3) X–Y.
http://timreview.ca/article/ZZZZ

Keywords: research and development, supplier involvement, outsourcing, partner selection, decision tool