Vaasan yliopisto
UNIVERSITY OF VAASA
OSUVA Open Science

This is a self-archived – parallel published version of this article in the publication archive of the University of Vaasa. It might differ from the original.

Boundaries of R&D Collaboration

Author(s): Bäck, Iivari; Kohtamäki, Marko

Title: Boundaries of R&D Collaboration

Year: 2015

Version: Accepted manuscript

Copyright ©2015 Elsevier. This manuscript version is made available under the Creative Commons Attribution–NonCommercial–NoDerivatives 4.0 International (CC BY–NC–ND 4.0) license, https://creativecommons.org/licenses/by-nc-nd/4.0/

Please cite the original version:

Bäck, I., & Kohtamäki, M. (2015). Boundaries of R&D Collaboration. *Technovation* 45-46, 15-28. https://doi.org/10.1016/j.technovation.2015.07.002

BOUNDARIES OF R&D COLLABORATION

Iivari Bäck*

Assistant Professor

University of Vaasa, Department of Management

PO Box 700, FI-65101 Vaasa, Finland

E-Mail: iivari.back@uva.fi

Marko Kohtamäki

Professor / Visiting Professor

University of Vaasa, Department of Management /

Entrepreneurship and Innovation, Luleå University of Technology

PO Box 700, FI-65101 Vaasa, Finland

E-Mail: marko.kohtamaki@uva.fi

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 & 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 & 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 & 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 & Zhang 2011; Eng & Wong 2006), competence (Verona 1999; Yasuda 2005), power (Gulati & Sytch 2007; Mayer & 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 & Eisenhardt 2005) in the context of R&D collaboration. Second, the study contributes to firm boundary literature by complementing the 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 & 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 & Schoonhoven 1996; Lavie 2006), suggesting that firms are continuously searching for resources and processes (Long & Vickers-Koch 1995) to configure combinations that function as a source of competitive advantage (Santos & 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 & 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 & Mitchell 2009), and to share the costs and risks of innovation (Eisenhardt & 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 & 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 & Eisenhardt 2005), such as asset specificity, and environmental and behavioral uncertainty (Rindfleisch & Heide 1997; Williamson 1975; Williamson 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 & 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 & Chu 2003). This therefore suggests that the competence view may outweigh transactional efficiency in terms of boundary formation in these dynamic environments (Santos & 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, Partanen & Möller 2013). Therefore, transaction costs, caused by monitoring and meeting practices, processes, and agreements (Rindfleisch & Heide 1997), may have a significant effect on boundary decisions (Eng & 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 & 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 & Sytch 2007), and therefore make partner switching costly (Heide & Weiss 1995). Consequently, firms

either have to tolerate being dependent on suppliers to enhance R&D performance (Gulati & Sytch 2007), or bring strategically crucial development projects in-house to avoid dependency, and then lose access to their partners' competences (Mayer & 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 & Eisenhardt 2005, p.499; Mayer & Nickerson 2005). On the other hand, if the relationship is coordinated properly, the partners' mutual dependence (Davis & Eisenhardt 2011; Gulati & 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 & 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 & 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 & Dukerich 1991; Kogut & Zander 1996; Brown & 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 & 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 & 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 & Eisenhardt 2005, p.502; Brown & 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 & Sutton 1991), leading to boundary reconsiderations (Santos & Eisenhardt 2005, p.502).

[Table 1 approximately here]

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 & Araujo 2007; Beverland & Lindgreen 2010).

[Table 2 Approximately here]

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 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 minutes, 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.

[Table 3 approximately here]

3.3. Reliability of the study

To increase the *reliability* of the study, a data triangulation technique was applied (Beverland & Lindgreen 2010; Huberman & 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 vice 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 expertise 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 & 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 & 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 & 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 & 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, Partanen, Parida, 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 & 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 & Sytch 2008; Rindfleisch & 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 & 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 & 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, feed back into increased trust in, and commitment to, the relationship on the customer side (Brennan & Turnbull 1999). Another measure of trust in the relationship is the role of written agreements, which are also key to governing cost (Santos & Eisenhardt 2005; Leiblein & 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 & 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, Partanen & Möller 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 & 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 & 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 & 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 & Sytch 2008; Rindfleisch & 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 & 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 & Sallis 2003; Kale et al. 2000; Kohtamäki, Partanen & Möller 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 & 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 re-considered 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 & Eisenhardt 2005). In this view, an organization's identity guides and activates individuals' motivations for action (Dutton & 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 & 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 & 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 & 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 & Eisenhardt 2005, p.502; Louis & 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.

[Figure 1 approximately here]

5. DISCUSSION AND CONCLUSIONS

5.1. Theoretical implications

Building on relational theories (Santos & 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 organizational theories. 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 (Figure 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 & Schoonhoven 1996). The results emphasize the meaning of 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 & 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 & Heide 1997; van Echtelt et al. 2008; Gulati & 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 & 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 & 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 & 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 & 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 & Eisenhardt 2011; Gulati & 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 & 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 & Eisenhardt 2005, p.499; Mayer & 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 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 & Starkey 2000; Santos & 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 & 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.

[Table 4 approximately here]

5.2. Managerial implications

Managers make decisions based on their interpretations of the environment (Daft & 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.

6. REFERENCES

Adler, P.S., 2001. Market, hierarchy, and trust: The knowledge economy and the future of capitalism. *Organization Science*, 12(2), pp.215–234.

Artz, K.W. et al., 2010. A Longitudinal Study of the Impact of R&D, Patents, and Product Innovation on Firm Performance. *Journal of Product Innovation Management*, 27(5), pp.725–740.

Athaide, G.A. & Zhang, J.Q., 2011. The Determinants of Seller-Buyer Interactions during New Product Development in Technology-Based Industrial Markets. , 28, pp.146–158.

Barney, J.B., 1999. How a Firm's Capabilities Affect Boundary Decisions. *Sloan Management Review*, 40(3), pp.137–146.

Beverland, M. & Lindgreen, A., 2010. What makes a good case study? A positivist review of qualitative case research published in Industrial Marketing Management, 1971–2006. *Industrial Marketing Management*, 39(1), pp.56–63.

Brennan, R. & Turnbull, P.W., 1999. Adaptive behavior in buyer–supplier relationships. *Industrial Marketing Management*, 28(5), pp.481–495.

Brown, A.D. & Starkey, K., 2000. Organizational Identity and Learning: A Psychodynamic Perspective. *The Academy of Management Review*, 25(1), p.102.

Corsaro, D., Cantù, C. & Tunisini, A., 2012. Actors' Heterogeneity in Innovation Networks. *Industrial Marketing Management*, 41(5), pp.780–789.

Daft, R.L. & Weick, K.E., 1984. Toward a Model of Organizations as Interpretation Systems. *Academy of Management Review*, 9(2), pp.284–295.

Davis, J.P. & Eisenhardt, K.M., 2011. Rotating Leadership and Collaborative Innovation: Recombination Processes in Symbiotic Relationships. *Administrative Science Quarterly*, 56(2), pp.159–201.

Dubois, A. & Araujo, L., 2007. Case research in purchasing and supply management: Opportunities and challenges. *Journal of Purchasing and Supply Management*, 13(3), pp.170–181.

Dutton, J.E. & Dukerich, J.M., 1991. Keeping an Eye on the Mirror: Image and Identity in Organizational Adaptation. *Academy of Management Journal*, 34(3), pp.517–554.

Dyer, J.H., 1996. Does Governance Matter ? Keiretsu Alliances and Asset Specificity as Sources of Japanese Competitive Advantage. *Organization Science*, 7(6), pp.649–666.

Dyer, J.H. & Chu, W., 2003. The Role of Trustworthiness in Reducing Transaction Costs and Improving Performance: Empirical Evidence from the United States, Japan, and Korea. *Organization Science*, 14(1), pp.57–68.

Van Echtelt, F.E. a. et al., 2008. Managing Supplier Involvement in New Product Development: A Multiple-Case Study. *Journal of Product Innovation Management*, 25(2), pp.180–201.

Eisenhardt, K., 1989. Building theories from case study research. *The Academy of Management Review*, 14(3), pp.532–550.

Eisenhardt, K.M. & Martin, J.A., 2000. Dynamic capabilities, what are they? *Strategic Management Journal*, 21, pp.1105–1121.

Eisenhardt, K.M. & Schoonhoven, C.B., 1996. Resource-based View of Strategic Alliance Formation : Strategic and Social Effects in Entrepreneurial Firms. *Organization Science*, 7(2), pp.136–151.

Eng, T.-Y. & Wong, V., 2006. Governance mechanisms and relationship productivity in vertical coordination for new product development. *Technovation*, 26(7), pp.761–769.

Gulati, R., 1998. Alliances and networks. *Strategic Management Journal*, 19(4), pp.293–317.

Gulati, R. & Sytch, M., 2007. Dependence asymmetry and joint dependence in interorganizational relationships: Effects of embeddedness on a manufacturer's performance in procurement relationships. *Administrative Science Quarterly*, 52(1), pp.32–69.

Gulati, R. & Sytch, M., 2008. Does Familiarity Breed Trust ? Revisiting the Antecedents of Trust. *Managerial and Decision Economics*, 29, pp.165–190.

Hagedoorn, J., Roijakkers, N. & Kranenburg, H., 2006. Inter-Firm R&D Networks: the Importance of Strategic Network Capabilities for High-Tech Partnership Formation1. *British Journal of Management*, 17(1), pp.39–53.

Heide, J.B. & Weiss, A.M., 1995. Vendor Consideration and Switching Behavior for Buyers in High-Technology Markets. *Journal of Marketing*, 59(July), pp.30–43.

Huberman, M. & Miles, M., 1994. Data management and analysis methods. In N. Denzin & Y. Lincoln, eds. *Handbook of qualitative research*. London: Thousand Oaks, pp. 428–444.

Huikkola, T., Ylimäki, J. & Kohtamäki, M., 2013. Joint learning in R&D collaborations and the facilitating relational practices. *Industrial Marketing Management*, 42(7), pp.1167–1180.

Johnsen, T.E., 2009. Supplier involvement in new product development and innovation: Taking stock and looking to the future. *Journal of Purchasing and Supply Management*, 15(3), pp.187–197.

Kale, P., Singh, H. & Perlmutter, H., 2000. Learning and protection of proprietary assets in strategic alliances: building relational capital. *Strategic Management Journal*, 21(3), pp.217–237.

Kogut, B. & Zander, U., 1996. What Firms Do? Coordination, Identity, and Learning. *Organization Science*, 7(5), pp.502–518.

Kohtamäki, M. et al., 2012. Enabling relationship structures and relationship performance improvement: The moderating role of relational capital. *Industrial Marketing Management*.

Kohtamäki, M., Partanen, J., Parida, V., et al., 2013. Non-linear relationship between industrial service offering and sales growth: The moderating role of network capabilities. *Industrial Marketing Management*, 42(8), pp.1374–1385.

Kohtamäki, M., Partanen, J. & Möller, K., 2013. Making a profit with R&D services — The critical role of relational capital. *Industrial Marketing Management*, 42(1), pp.71–81.

Lavie, D., 2006. The competitive advantage of interconnected firms: An extension of the resource-based view. *Academy of Management Review*, 31(3), pp.638–658.

Leiblein, M.J. & Miller, D.J., 2003. An empirical examination of transaction- and firm-level influences on the vertical boundaries of the firm. *Strategic Management Journal*, 24(9), pp.839–859.

Lewicki, R.J., Tomlinson, E.C. & Gillespie, N., 2006. Models of Interpersonal Trust Development: Theoretical Approaches, Empirical Evidence, and Future Directions. *Journal of Management*, 32(6), pp.991–1022.

Long, C. & Vickers-Koch, M., 1995. Using core capabilities to create competitive advantage. *Organizational Dynamics*, 24(1), pp.7–22.

Louis, M.R. & Sutton, R.I., 1991. Switching Cognitive Gears: From Habits of Mind to Active Thinking. *Human Relations*, 44(1), pp.55–76.

Mayer, K.J. & Nickerson, J. a., 2005. Antecedents and Performance Implications of Contracting for Knowledge Workers: Evidence from Information Technology Services. *Organization Science*, 16(3), pp.225–242.

Parmigiani, A. & Mitchell, W., 2009. Complementarity, capabilities, and the boundaries of the firm: the impact of within-firm and interfirm expertise on concurrent sourcing of complementary components. *Strategic Management Journal*, 30, pp.1065–1091.

Porter, M.E., 2008. The five competitive forces that shape strategy. *Harvard business review*, 86(1), pp.78–93, 137.

Quinn, J.B., 2000. Outsourcing Innovation : The New Engine of Growth. *Sloan*, pp.13–28.

Rindfleisch, A. & Heide, J.B., 1997. Transaction Cost Analysis : Past, Present, and Future Applications. *Journal of Marketing*, 61, pp.30–54.

Ritter, T. & Gemünden, H.G., 2003. Network competence. *Journal of Business Research*, 56(9), pp.745–755.

Santos, F.M. & Eisenhardt, K.M., 2005. Organizational Boundaries and Theories of Organization. *Organization Science*, 16(5), pp.491–508.

Selnes, F. & Sallis, J., 2003. Relationship Promoting Learning. , 67(3), pp.80–95.

Sobrero, M. & Roberts, E.B., 2002. Strategic management of supplier–manufacturer relations in new product development. *Research Policy*, 31(1), pp.159–182.

Stump, R.L., Athaide, G. a. & Joshi, A.W., 2002. Managing seller-buyer new product development relationships for customized products: a contingency model based on transaction cost analysis and empirical test. *Journal of Product Innovation Management*, 19(6), pp.439–454.

Teece, D.J., Pisano, G. & Shuen, A.M.Y., 1997. Dynamic capabilities and strategic management. *Strategic Management Journal*, 18(7), pp.509–533.

Tripsas, M., 2009. Technology, Identity, and Inertia Through the Lens of "The Digital Photography Company." *Organization Science*, 20(2), pp.441–460.

Wagner, S.M. & Hoegl, M., 2006. Involving suppliers in product development: Insights from R&D directors and project managers. *Industrial Marketing Management*, 35(8), pp.936–943.

Walsh, J.P., 1995. Managerial and Organizational Cognition: Notes from a Trip Down Memory Lane. *Organization Science*, 6(3), pp.280–321.

Walter, A., 2003. Relationship-specific factors influencing supplier involvement in customer new product development. *Journal of Business Research*, 56(9), pp.721–733.

Weick, K.E., Sutcliffe, K.M. & Obstfeld, D., 2005. Organizing and the Process of Sensemaking. *Organization Science*, 16(4), pp.409–421.

Verona, G., 1999. A resource-based view of product development. *Academy of Management Review*, 24(1), pp.132–142.

Williamson, O., 1975. *Markets and hierarchies*, Free Press.

Williamson, O.E., 2008. Outsourcing: transaction cost economics and supply chain management. *Journal of supply chain management*, 44(2), pp.5–16.

Yasuda, H., 2005. Formation of strategic alliances in high-technology industries: comparative study of the resource-based theory and the transaction-cost theory. *Technovation*, 25(7), pp.763–770.

Yin, R., 1994. *Case study research: Design and methods*, London: SAGE Publications.

Zaheer, A. et al., 1998. Does Trust Matter ? Exploring the Effects of Interorganizational and Interpersonal Trust on Performance. *Organization Science*, 9(2), pp.141–160.

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-A2 B1-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-A4 B5-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-A7 B13-B14
Identity	Organizational identity, managerial cognition	Collective sensemaking of organizational members	Tends to maintain existing practices (status quo)	Managerial sensemaking	A8-A10

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€	1M€	1M€	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[1]; 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

[1] 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	-

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	-

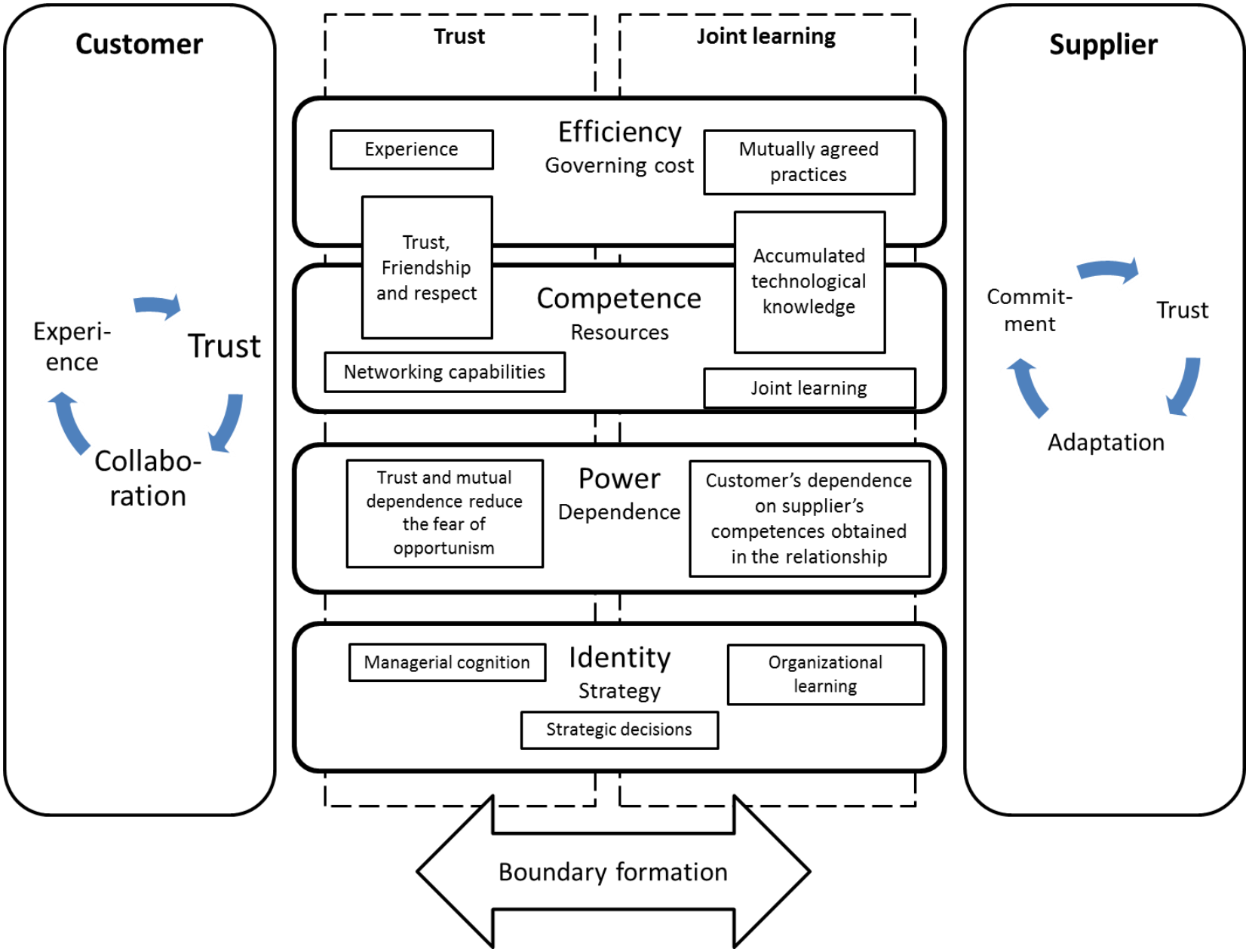

Figure 1. Factors affecting boundary formation in long-term R&D collaboration between customer and suppliers.

APPENDIX 1: WITHIN-CASE TABLE BASED ON CASE INTERVIEWS.

Topic	Supplier A	Supplier B	Supplier C	Supplier D	Supplier E	Supplier F
1. 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.
2. COMPETENCE						

Topic	Supplier A	Supplier B	Supplier C	Supplier D	Supplier E	Supplier F
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.
			3. POWER			
1. How expensive or difficult would the insourcing of the services provided by the partner be for the customer?	Due to overlapping competences, insourcing would not be difficult. However, it would require a considerable amount of new capacity.	Insourcing would require several new employees, and investment in new tools and systems for documentation and information design.	Insourcing would require several new designers, and training existing employees.	Insourcing would require several new designers, acquiring new competences, and training existing employees.	Insourcing would be very difficult. It would be difficult to find several new designers with specific competences.	Insourcing would require very large investments in 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?