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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.

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 (Reilly & Sharkey Scott 2014; Mudambi et al. 2007), the role of external R&D suppliers in the product development and innovation activities of multinationals continues to grow (Johnsen 2009; Wagner & Hoegl 2006; Quinn 2000). 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 (Huikkola et al. 2013; Davis & Eisenhardt 2011; Un et al. 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 (Stuart 2000; Powell et al. 1996), between supplier and customer (Johnsen 2009; Quinn 2000; Wagner & Hoegl 2006), and also in collaborations between a parent R&D organization and its subsidiaries (Reilly & Sharkey Scott 2014; Figueiredo 2010; Andersson et al. 2002). 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, have been neglected in the previous research on R&D collaboration (Davis & Eisenhardt 2011, pp.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 (Selnes & Sallis 2003; Dyer & Singh 1998; Davis & Eisenhardt 2011; Kale & Singh 2007). 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 (Selnes & Sallis 2003; Huikkola et al. 2013; Chang & Gotcher 2007), and because joint learning has a clear positive impact on a firm's innovative performance (Duysters & 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 (Hurley & Hult 1998, p.44; Fang et al. 2011). 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 & 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.

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 (Selnes & Sallis

2003; Kuwada 1998) and the literature concerned with R&D collaboration with external suppliers (Johnsen 2009; Quinn 2000; Wagner & Hoegl 2006), and with internal subsidiary partners (Reilly & Sharkey Scott 2014; Figueiredo 2010; Andersson et al. 2002). 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). 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 (Un et al. 2010; Gulati 1998; Nieto & Santamaría 2007). In developing the necessary technological capabilities, cross-functional teams and routines, knowledge creation and knowledge transfer are important elements (Eisenhardt & Martin 2000, p.1108). In particular, innovativeness—defined as the "capacity to introduce some new process, product, or idea in the organization" (Hult et al. 2004; Hurley & Hult 1998)—is largely dependent on cumulative knowledge, shared experience, and learning occurring between R&D collaboration partners (Hoecht & Trott 2006; Nieto & Santamaría 2007; Fang et al. 2011). 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 & Hoegl 2006).

2.2. Joint learning in R&D collaboration

Organizational learning (Kuwada 1998), has been widely conceptualized as a dynamic capability (Kale & Singh 2009; Teece et al. 1997) and an antecedent of innovation (e.g., Hurley & Hult 1998, p.44; Fang et al. 2011). 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 & Katila 2001; Duysters & Lokshin 2011; Brown & Eisenhardt 1997; Lin et al. 2012; Bäck & Kohtamäki 2015). The present study builds on the work of (Selnes & 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 et al. 2013).

Knowledge sharing refers to the transfer of knowledge through formal and informal interaction between the parties (Chang & Gotcher 2007; Selnes & Sallis 2003) generated to transfer and absorb new knowledge from external relationships (Corsaro et al. 2012, p.780). Information asymmetries caused by inadequate information sharing can generate considerable transaction costs in the relationship (Baldwin 2007; Rindfleisch & Heide 1997; Stump et al. 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 et al. 2008; Martinez-Noya et al. 2013). Hence, effective R&D collaboration requires the sharing of tacit R&D knowledge between partners in an open atmosphere (Garvin 1993; Kohtamäki & Bourlakis 2012), in which the role of in-depth interaction (Grönroos & Voima 2013), dialogue (Ballantyne et al. 2011), and learning (Chang & Gotcher 2007; Huikkola et al. 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 et al. 2001; Yamin & Andersson 2011; Reilly & Sharkey Scott 2014). 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 (Gulati & Sytch 2007; Bäck & Kohtamäki 2015).

Joint sense-making aims at achieving a common understanding through the social process operating between parties (Weick et al. 2005) by building consensus through finding an appropriate fit between partners' expectations and capabilities (Chang & Gotcher 2007; Huikkola et al. 2013). This is often challenging in the relational context, in which physical, psychological, and cultural distances between actors can be significant (Huikkola et al. 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 (van Echtelt et al. 2008; Sobrero & Roberts 2002; Bäck & Kohtamäki 2015).

Knowledge integration into relationship-specific memory involves the integration of knowledge into relation-specific memories developed by organizations (Selnes & Sallis 2003). These knowledge-based resources spanning firm boundaries are embedded as interfirm resources (Dyer & Singh 1998), and may be related to relational structures, working procedures, routines, products, or services (Johnson et al. 2004; Moorman & Miner 1997; Lukas et al. 1996). In this paper, the concept is referred to as *knowledge implementation* or *institutionalization* (Crossan et al. 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 (Moorman & Miner 1997; Lukas et al. 1996). 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 (Dubois & Araujo 2007; Beverland & Lindgreen 2010).

[*Insert Tables 1 & 2 around here*]

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 experience of and responsibility for the focal relationship. The interviews lasted between 61 and 250 minutes, 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 & Lindgreen 2010; Huberman & Miles 1994; Huikkola et al. 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.

[*Table 3 approximately here*]

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 United States. These three sub-units 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 et al. 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 et al. 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.

4.2.1. Knowledge sharing

Tsai (2001, p.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 et al. 2008; Mudambi et al. 2007; Tsai 2001; Reilly & Sharkey Scott 2014).

> *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 & 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; Yamin & Andersson 2011; Mcevily & Zaheer 1999), and integrating technological capabilities and competences developed in subsidiaries is an important task for the lead unit (Birkinshaw & 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 & Zander 1996). However, a number of scholars have listed barriers to internal knowledge transfer as well (Monteiro et al. 2008; Lane & Lubatkin 1998; 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 et al. 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 (Szulanski 1996; Lane & Lubatkin 1998; Monteiro et al. 2008). 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 & 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 et al. 2013). Furthermore, establishing a common understanding requires discussion (thus a psychological proximity) (Kogut & 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 et al. 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 et al. 2005), and its central goal in the relational context is to find an appropriate fit between partners' expectations and capabilities (Chang & Gotcher 2007; Huikkola et al. 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 et al. 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 et al. 2001; Yamin & Andersson 2011; Reilly & Sharkey Scott 2014).

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 USA unit, with which the collaboration is closest. Furthermore, previous research suggests that embeddedness and the subsidiary's potential to contribute to technological development across internal organizational boundaries are related (Yamin & Andersson 2011; Andersson et al. 2002; Figueiredo 2010; Reilly & Sharkey Scott 2014). This study's data is 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 (Yamin & Andersson 2011; Andersson et al. 2001; Cantwell & Mudambi 2005; Figueiredo 2010)

> *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 & 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 & 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 & 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 supports the conclusions drawn by others that experience accumulated in joint projects can result in more efficient collaboration and innovativeness in future projects (van Echtelt et al. 2008; Ragatz et al. 1997; Sobrero & Roberts 2002; Nieto & Santamaría 2007). 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 (Selnes & Sallis 2003; Kohtamäki et al. 2013; Kale et al. 2000):

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 (Selnes & Sallis 2003; Coulter & Coulter 2003; Kale et al. 2000). 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 & Sallis 2003) is often referred as knowledge implementation or institutionalization (Crossan et al. 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 et al. 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 & 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 & 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 et al. 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 et al. 2005; Birkinshaw & Hood 1998; Monteiro et al. 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 USA 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 (Selnes & Sallis 2003; Kale et al. 2000). 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 & Hoegl 2006; Walsh 1995). Hence, jointly created and shared knowledge is stored in a relationship-specific memory (Moorman & 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)

[*Figure 1 approximately here*]

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 (Yamin & Andersson 2011; Andersson et al. 2001) and the external form (Brennan & Turnbull 1999; Walter 2003). Our data is 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 (van Echtelt et al. 2008; Sobrero & Roberts 2002). 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 (Yamin & Andersson 2011; Andersson et al. 2002; Figueiredo 2010) and external relationships (Nieto & 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 (Kale et al. 2000; Selnes & Sallis 2003; Coulter & Coulter 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 & Santamaría 2007; Wagner 2010), whereas distrust may lead to negative spirals of opportunistic behavior (Ghoshal & 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 et al. 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.

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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**

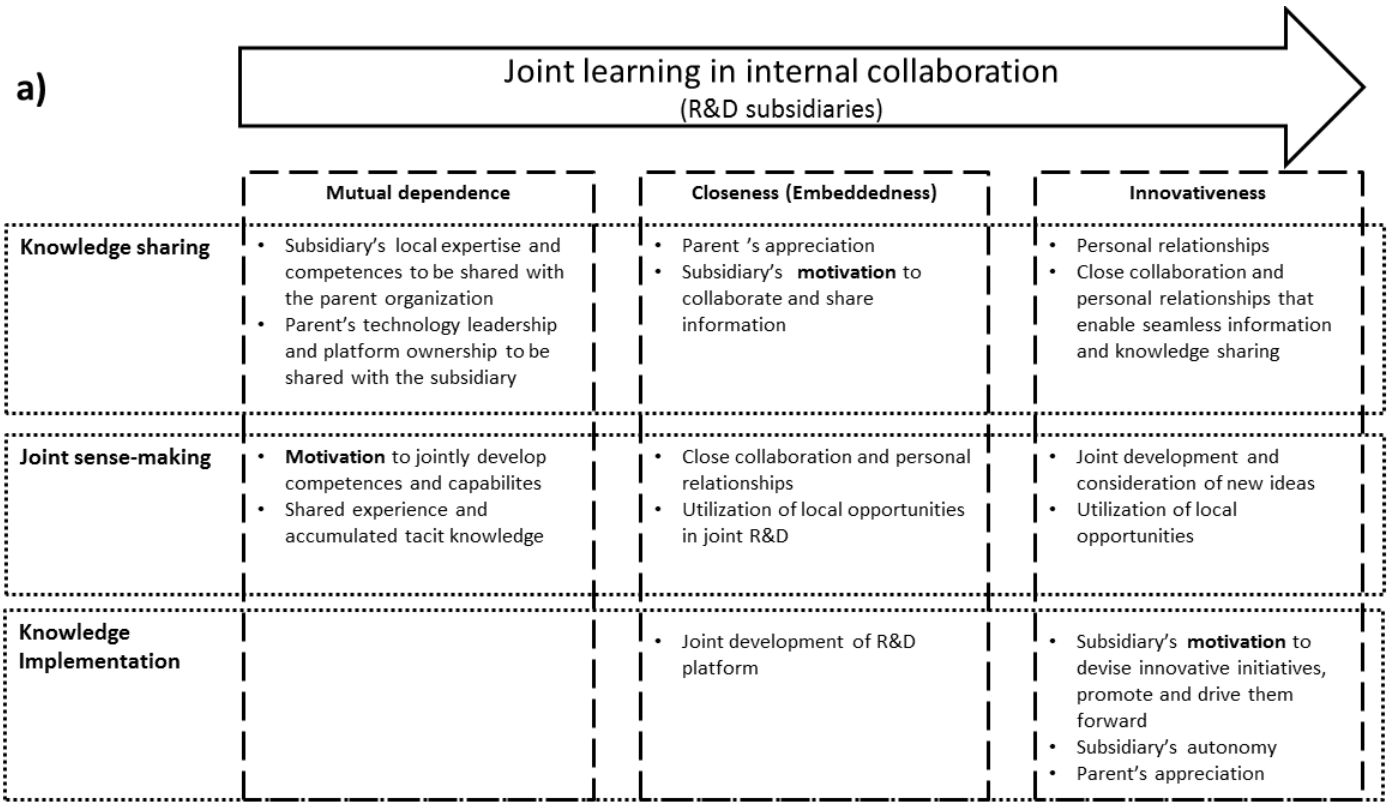
Table 2. Case descriptions for the studied relationships between lead R&D unit and its external partners (R&D suppliers).

	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%
Duration of the collaboration	14 years	4 years	10 years
Participants in the case interview (supplier)	CEO[1] 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

[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 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)	-



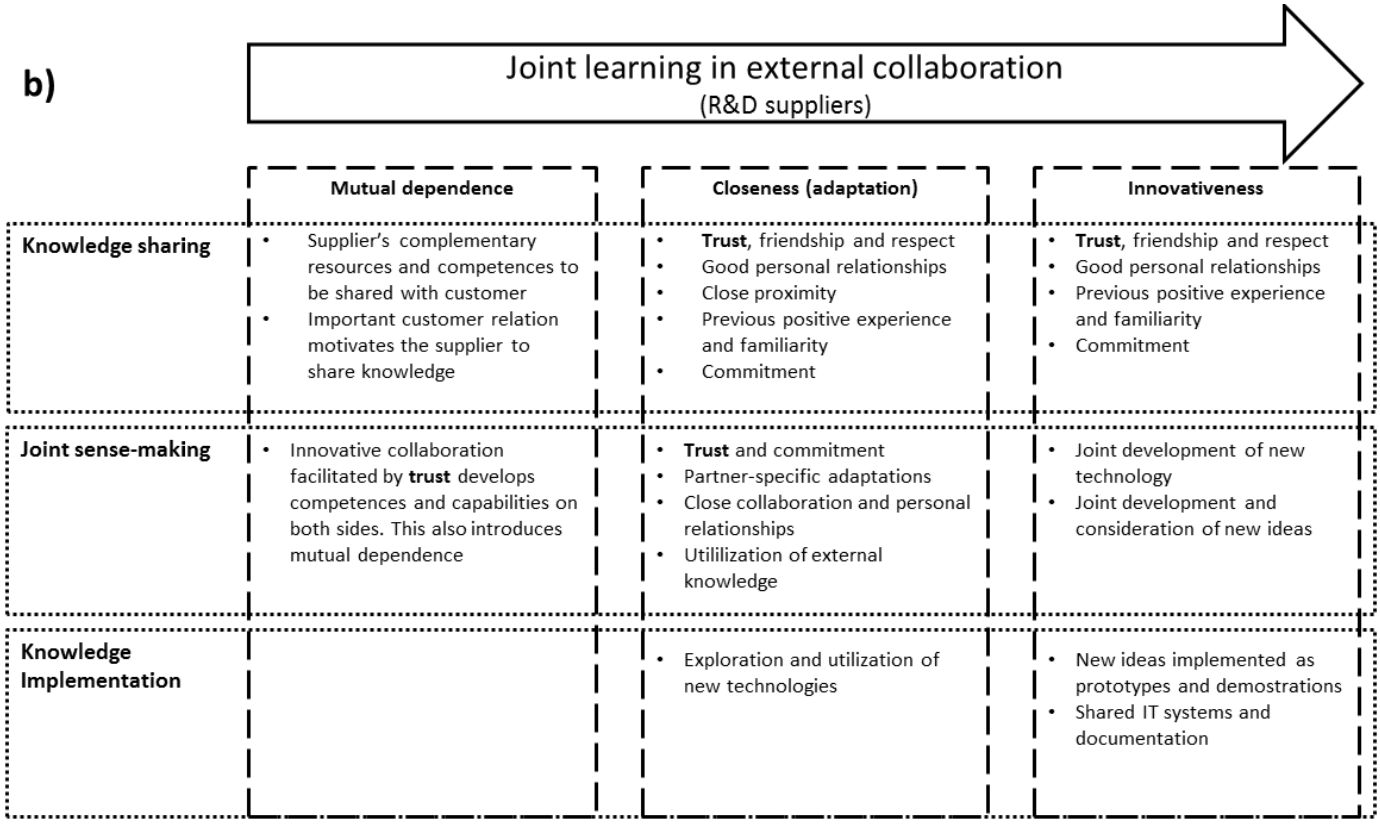


Figure 1. The facilitators of joint learning in the R&D network containing a) internal and b) external relations.