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Research Article

Knowledge Creation and Exploitation in Collaborative R&D Projects: Lessons Learned on Success Factors

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Abstract: This paper examines the management of collaborative R&D projects with customers. Prior research on social network theory and the knowledge-based view has identified the conditions of successful collaboration, whereas the actual management of project dynamics has received less attention. This paper addresses this gap in extant research through a case study on the management of inter-firm R&D projects in a large European telecommunications operator. It provides a cross-case comparison on the process of knowledge creation and exploitation in five collaborative R&D projects with customers. The objective is to increase current understanding on the success factors of collaborative R&D projects. As a result of this paper, the creation of a genuine "win-win" situation, clear roles and responsibilities, the customer-oriented approach and the exchange of complementary specialist knowledge are found as the most critical success factors in the process of inter-firm knowledge creation. Moreover, this paper indicates the viability of the business opportunity to be the primary success factor in knowledge exploitation. In addition to these success factors, the paper provides a more complete list of lessons learned from collaborative R&D projects with customers.

INTRODUCTION

The number of research and development (R&D) partnerships has grown significantly during the past decades, especially in high-tech industries (Hagedoorn, 2002). According to the social network theory and the knowledge-based view, collaboration enhances the competitive advantage of firms through enabling resource exchange and combination (Galunic and Rodan, 1998; Nahapiet and Ghoshal, 1998). Prior research has empirically demonstrated inter-firm cooperation to increase the innovativeness of

firms (Dutta and Weiss, 1997; Mitchell and Singh, 1992; Mowery *et al.*, 1996; Stuart, 2000). Especially, customers and suppliers provide an important source of innovation (von Hippel, 1988).

Furthermore, the social network theory and the knowledge-based view have described the necessary conditions of inter-firm knowledge creation. While prior research has focused on the process of initiating collaborations, there are still little studies that examine their actual implementation (Doz, 1996; Gerwin, 2004). Although planning of collaborative projects is crucial, the success of these projects ultimately depends on how well they are executed. In fact, despite the great potential of inter-firm collaborative projects, prior research has found a large proportion of them to end as failures (Doz, 1996; Gulati, 1998; Khanna *et al.*, 1998). This paper examines the evolution of collaborative R&D projects and seeks to understand why some partnerships fail to achieve their objectives, while others succeed in this. The research question is "What are the success factors of collaborative R&D projects with customers that contribute to the fulfillment of favorable conditions of knowledge creation and exploitation?" This paper aims at contributing to both management theory and practice through increasing the current understanding on the success factors of collaborative R&D projects.

This paper is based on a case study method. This approach has been chosen in order to be able to get a deeper understanding on the actual dynamics of collaborative R&D projects with customers. The case company is a large European telecommunications operator, which has recently developed a new practice of innovation with customers. The primary data is acquired from five of these collaborative R&D projects with customers through interviewing the key project participants.

This paper is organized as follows. First, it presents a brief theoretical background. Second, it clarifies the research method and the data used in this paper. Third, it provides a short description of the case company and the case projects and then presents the results of cross-case comparison. Fourth, the paper closes with the discussion and conclusions on the lessons learned on the success factors of collaborative R&D projects.

THEORETICAL BACKGROUND

Social network theory

The social network theory emphasizes relational resources as a source of competitive advantage for firms (Adler and Kwon, 2002; Granovetter, 1985; Nahapiet and Ghoshal, 1998). It originates from the sociological theory. The seminal work of Granovetter (1985) suggested most behavior to be embedded in networks of inter-personal relations, which account for much of the order found in markets and firms. Nahapiet and Ghoshal (1998) defined social capital as the sum of actual and potential resources embedded within, available through and derived from the network of relationships that an individual or a social unit possesses. Social capital enhances the creation of new intellectual capital through resource exchange and combination, when the following conditions are met (Nahapiet and Ghoshal, 1998). First, the parties need to have access to each other. Second, they need to expect that the resource exchange and combination creates value. Third, they must be motivated for resource exchange and combination. Fourth, they need to be able to combine resources with each other.

Furthermore, social capital consists of structural, relational and cognitive dimensions (Nahapiet and Ghoshal, 1998). Prior research has demonstrated how these dimensions influence the creation of intellectual capital. Having both direct and indirect network ties with other firms enhance the innovation performance (Ahuja, 2000; Tsai and Ghoshal, 1998). Also, a bridging position between structural holes i.e. firms connecting otherwise disconnected contacts is advantageous (Burt, 1992; Moran, 2005; Rodan and Galunic, 2004). Moreover, the similarity of organizational structures, compensation policies and dominant logics between partners as well as trust and alliance management capability enhance resource exchange and combination (Anand and Khanna, 2000; Gulati, 1988; Lane and Lubatkin, 1998).

One of the main process-oriented studies on the evolution of collaborative R&D projects is the study of Doz (1996), which indicates that alliance projects can only be successful, if the project partners are able to continuously learn, re-evaluate and readjust the initial conditions of partnership. Tension in inter-firm cooperation may become critical because of the conflicting pressures of simultaneous competition and cooperation. If the private benefits of partners are higher than the common benefits, then their incentives to invest in learning diminish (Khanna *et al.*, 1998). Other common problems in inter-firm project management have been found to arise from different

methods of planning and managing projects, lack of a joint governance mechanism and reporting system, different interpretations and communication channels, unclear responsibilities, different perceptions of quality and change management (Pelin, 1996).

The knowledge-based view of the firm

The knowledge-based view emphasizes knowledge-based resources as a source of competitive advantage (Grant, 1996; Nonaka and Takeuchi, 1995; Spender, 1996). Knowledge heterogeneity and the difficulty of transferring it enable knowledge to provide competitive advantage (Galunic and Rodan, 1998; Grant, 1996; Kogut and Zander, 1992). The firm-external relationships are especially beneficial in the search of knowledge, as they are more likely to provide novel and nonredundant knowledge than firm-internal relationships (Granovetter, 1973). While the majority of prior research has emphasized alliances to enhance the acquisition of knowledge from a partner firm, recently Grant and Baden-Fuller (2004) proposed that alliances are primarily used for knowledge access facilitating the integration of knowledge between partners. In this type of collaboration, both partners intend to maintain their distinctive base of specialized knowledge, rather than to acquire the knowledge of their partners (Grant and Baden-Fuller, 2004). According to the knowledge accessing theory of alliances, the primary benefit of inter-firm collaboration derives from exploiting knowledge complementarities between partners (Grant and Baden-Fuller, 2004). By knowledge complementarities it is meant that the knowledge base of partners is dissimilar, but complementary in a sense that it is possible to develop valuable new knowledge combinations through joint knowledge sharing.

The characteristics of knowledge, which influence the usage of knowledge, are appropriability, transferability and the capacity to aggregation (Grant, 1996). Appropriability refers to the ability of the knowledge owner to receive a return equal to the value created by the knowledge (Grant, 1996). Due to appropriation concerns, trust and/or a formal partnership agreement are needed in collaborative R&D projects to protect knowledge owners (Gulati and Singh, 1998). The tacitness, context specificity and complexity make knowledge difficult to transfer between firms (Galunic and Rodan, 1998; Grant, 1996; Kogut and Zander, 1992). Strong ties i.e. close and frequent

relationships are needed in transferring tacit and complex knowledge (Hansen, 1999). Moreover, successful knowledge transfer requires absorptive capacity, which means that the recipient need to be able to value, assimilate, and utilize new knowledge (Cohen and Levinthal, 1990; Grant, 1996).

Prior research has demonstrated the following conditions for knowledge-based resources that influence the creation of intellectual capital. First, novel and nonredundant knowledge acquired from firm-external relationships enhances the radicalness of innovation (Landry *et al.*, 2002; Rosenkopf and Almeida, 2003). Second, knowledge heterogeneity increases the likelihood that new resources and opportunities are discovered more quickly (Granovetter, 1973) and improves the ability to exploit complex opportunities (Rodan and Galunic, 2004). Prior research has demonstrated knowledge heterogeneity to enhance managerial performance and innovativeness (Moran, 2005; Rodan and Galunic, 2004).

Theoretical framework

The theoretical framework of this paper, illustrated in Figure 1, is based on the social network theory and the knowledge-based view. The theoretical framework illustrates the conditions underlying the combination of relational and knowledge-based resources, which influence the creation of competitive advantage. The focus of this paper is in identifying the actual events, success factors that contribute to the fulfillment of the conditions of successful knowledge creation and exploitation in collaborative R&D projects with customers.

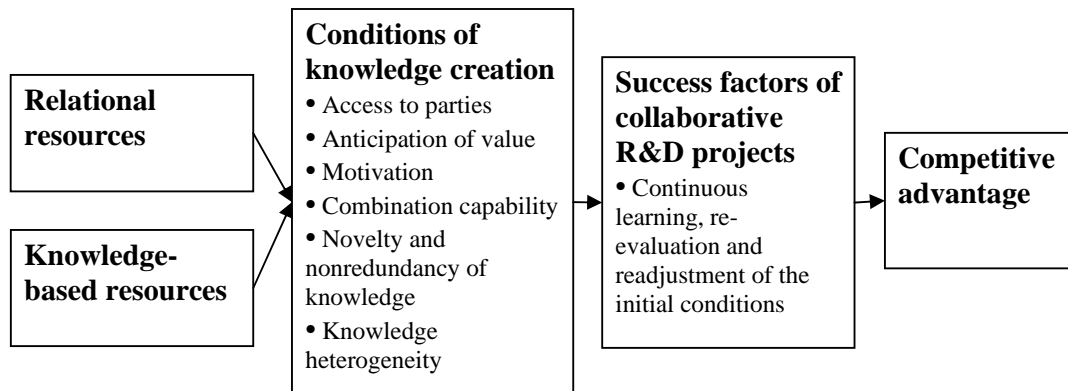


Figure 1 Theoretical framework

EMPIRICAL RESEARCH

Methods and data

This research takes a case study approach in order to be able to examine the dynamics of knowledge creation and exploitation in collaborative R&D projects with customers. The strength of a case study approach is its ability to generate novel, precise and empirically valid theories, but as a weakness it provides narrow and idiosyncratic results (Eisenhardt, 1989). The case company is a large European telecommunications operator, which is famous for its innovative services. It has recently built an innovation forum for collaborative service development with customers. Thus, the case company provided an interesting research setting on collaborative R&D projects. The innovation forum is a company-wide tool to collect customer insight for new business development and to test the feasibility of new service ideas with external parties. New service ideas are both created within innovation forum projects as well as extracted from other parts of the company or its partners. The innovation forum projects are based on new technologies, as well as on innovation in services, earning logics and business models. These projects aim at being 12-18 months ahead of market launch. The results of innovation forum projects can be utilized company-wide in different functional areas.

The case projects were chosen to represent both successful and unsuccessful collaborative projects in order to get a fruitful research setting for cross-case comparison. The primary research data was gathered through 60-90 minutes interviews with altogether six project participants in April-June 2004 and through direct observations in project meetings of one collaborative case project in April-June 2002. The secondary data was collected from project documents and presentations. This type of theoretical case sampling and the combination of multiple data collection methods is typical of case studies (Eisenhardt, 1989).

The theoretical framework was used to assist the formulation of interview questionnaire. The interview questions concerned the process of knowledge creation and exploitation in collaborative R&D projects with customers. A special attention was paid on what was made in the case projects to fulfill the conditions of successful knowledge creation and exploitation during the project evolution and the reasons behind.

The interviews were semi-structured in order to be able to receive comparable data from different case projects, but also to leave room for detailed explanations on the actual project dynamics.

The research data was first analyzed within each case project separately. Then, a cross-case comparison was used as a method to go beyond the initial impressions through searching systematically for patterns of similarities and differences across cases (Eisenhardt, 1989). The method of cross-case comparison enhances the reliability of the data analysis and decreases the likelihood of information processing biases (Eisenhardt, 1989). Finally, the results were summarized according to the lessons learned on the success factors of collaborative R&D projects with customers.

Description of case projects

This chapter compares the basic characteristics of the case projects, which is followed by a short description of the initial conditions and the progress of each case project separately. The case projects were named as Mobility, Multi-access, E-delivery, E-transaction and Communications. All of them occurred between the case company and one of its corporate customers. Two case projects also involved other partners such as equipment manufacturers or software providers. The goal of the operator and other partners was to create new business in all case projects. The goal of the corporate customer was either to improve its operational efficiency or to create new business as well. The scope of the case projects varied from focused projects to very wide and ambitious ones. The duration of the projects varied from three months to one year. There were two kinds of project contracts, pure pilot agreements in which all parties paid their own costs or sales agreements in which customer paid at least partly, the work of the operator. Table 1 presents the basic characteristics of the case projects.

Table 1 Basic characteristics of case projects

	Case: Mobility	Case: Multi-access	Case: E-delivery	Case: E-transaction	Case: Communications
Participants of the collaborative R&D project	Operator and its corporate customer	Operator and its corporate customer	Operator, its corporate customer and two other partners	Operator, its corporate customer and one other partner	Operator and its corporate customer
Goal	Create a new service concept that provides new business for both partners.	Create a new service concept that increases the operational efficiency of the customer & provides new business for the operator.	Create a new service concept that increases the operational efficiency of the customer & provides new business for the other partners.	Create a new service concept that increases the operational efficiency of the customer & provides new business for the other partners.	Create a new service concept that increases the operational efficiency of the customer & provides new business for the operator.
Project scope	Focused	Wide	Very focused	Very focused	Wide
Project duration	3/2003 – 12/2003	3/2001 – 3/2002	9/2003 – 12/2003	6/2003 – 4/2004	9/2001 – 6/2002
Type of contract	Pilot agreement (both parties pay their own costs)	Sales & pilot agreement (all customer-specific work paid by the customer)	Sales & pilot agreement (customer pays the project work, but receives a discount)	Pilot agreement (all parties pay their own costs)	Development project (both parties pay their own costs)

Case Mobility

This project was initiated on the basis of a close relationship between two persons in the companies involved. The companies had a long existing customer relationship, but no prior experience on joint service development. The persons that initiated the project took care of the initial project preparation within their respective companies. As a result, the project organization was named and the detailed project plan jointly created. The project structure and organization was kept light. The project team consisted of eight participants from different functions of the partnering firms.

The project progressed well according to the project plan. Anticipation of value and trust between the participants increased step-by-step through joint interaction, as both parties felt that they were learning and that project proceeded well. Service requirements were clearly communicated by the customer. The technical questions were well solved, as the knowledge bases of the partners were strong and they complemented well each other. The project meetings, which were organized twice a month, were

efficient following a structure of first sharing the project status together and then discussing new ideas for service features. The project scope widened from the actual plan as many new ideas were created in joint meetings. Some ideas were left to actual offering development, since they could not be completed with the existing project resources. Both project managers took the responsibility to drive the project in their respective companies, provide business insight and document the results. The participants also organized shared evenings as key project milestones were achieved.

The cooperation was successful and it resulted in a creation of a joint future service concept. However, as a disappointment for the whole project group in both companies, the actual service implementation was postponed. This was because the business potential seemed too weak for the operator.

Case Multi-access

This project was also initiated based on a relationship between two persons in partnering firms. They had a joint vision on how technology could be applied in the future to advance the operational efficiency of the customer. These two persons prepared a project agreement together and invited the project organization, altogether 11 participants. The project agreement involved three payments from the customer to the operator. The project itself was ambitious as it aimed at developing a totally new, large-scale solution in only six months.

The project consisted of three distinct phases: requirement specification, development of solution architecture and development of implementation plan. The partners met each other in average twice a month. The collaborative project suffered from different knowledge bases and project practices between the partners. The customer was not able to explain its requirements for the operator in enough detail. The customer claimed the project practices of the operator to be too bureaucratic. Moreover, the customer participants in the project had conflicting views on what kind of solution was needed and the operator participants how to implement the solution. At the end, one person from the operator side was changed in order to be able to continue the project. The customer participants claimed continuously to be too busy to join the project meetings. This created bad feelings between partners and also misunderstandings, as

there was not enough time to review the project documentation on the initial results. Due to all these difficulties, the project scope was narrowed from initially planned and the duration delayed in total of six months until the three project phases were finished.

The cooperation resulted in a creation of a new service concept. However, customer perceived the new service concept too expensive and not to fit with its narrowed business focus. The reason for changes in the customer organization, which it had not communicated to the operator, derived from the declined market conditions.

Case E-delivery

This project was initiated to develop a new technical solution for advancing the customer's delivery process. The customer contacted the operator, because it lacked the knowledge to develop this kind of a solution by itself. The operator invited two other partners in the project for creating a full service solution. All of the partners had two members in the project team. The project participants had joint meetings twice a month and the project steering group once a month.

The project began with the collection of customer requirements. Then, clear roles and responsibilities were given to all parties, which were based on a genuine "win-win" situation and true resource complementary. The partners were technically very professional and had complementing knowledge bases, which enhanced the project progress. The project progressed well, despite two partners having little resources, which sometimes caused delays in their responses.

The project manager of the operator consulted the customer and its stakeholders on regular basis. Most importantly he created process practices between the customer and its stakeholders, which did not exist before, but were necessary in order for the customer to derive value from the new technical solution. For example, the project manager defined guidelines for the customer on preparing electronic documents with a signature, sending the document to the stakeholders and for the stakeholders on handling the document properly. In addition, the project manager organized several training sessions for the customer and its stakeholders on utilizing the technical solution in their daily work routines.

As one group of customer stakeholders was change resistant, and the other a slow decision-maker, the project delayed slightly as their acceptance and cooperation was required for succeeding in solution implementation. The cooperation resulted in the creation of the new solution, which combined the existing services of the three partners. The customer was satisfied, and purchased also other complementary services from the operator.

Case E-transaction

This project was initiated on the basis of a standardization committee membership. Two of the companies involved invited the operator to join the project. This was the first inter-firm service innovation project between the parties. All of them were motivated to cooperate as the project aimed at developing a new service that would bring significant cost savings to the customer and new business for the others. It was possible to create clear roles and responsibilities for the parties involved. The partner provided industry-specific knowledge and applications, whereas the operator the communications solutions needed and the customer a real test environment.

Joint success criteria were defined at the beginning of the project. Also, joint project practices were developed through formulating a common terminology and discussing the industry-specific practices underlying the project. The communication between the partners was efficient, as direct links were established between specialists in partnering firms. The joint steering group was organized for decision-making, when needed. In practice, the decision-making was customer-driven. The customer caused the project to delay with four months due to internal reasons. The top management support and the experience of the project team contributed to the inter-firm project success. These supported the project progress in unusual situations e.g. in getting a permission to use the operator network as a test environment of the joint project.

The cooperation resulted in the creation of the feasible service concept, which two partners are currently planning as the basis of a new joint business. The customer was satisfied and will start implement the new service as well.

Case Communications

This project was initiated to communicate the possibilities of technical development to the customer and to ensure that the service development of the operator met the customer needs. The customer and the operator had a long history of the cooperation. In this cooperative project more emphasis was given to the development of the customer needs and requirements than in previous collaborations, which focused on technical development. The operator was responsible of coordinating the project and the customer was to actively participate in project steering group, workshops and interviews. There was also a separate project group for the partnership development in general. Altogether 30 participants from partnering firms participated in joint events.

The project group first identified five main development areas. These were analyzed in respective sub-projects, in two separate phases. The first phase concentrated on examining the development of basic communications services and the second phase on the development of advanced communications solutions. The work of the sub-projects was concluded with a joint service development plan that described separately each of the sub-projects. This description contained the current status of the customer and the operator, the new customer requirements and the operator's response to them.

The knowledge exchange between the partners was open as the project provided clear benefits for both parties. The quality and the fit of the knowledge base between the partners were in general very good. However, in the sub-project five the knowledge of the customer was too technical and thus the actual connection to operational business processes was left unexplained. One reason for this was that the contact persons from the customer side were only from corporate information technology (IT) management unit. In the other sub-projects, also business management participated in the project.

This cooperation resulted in the development of a joint service development plan, which serves as a basic guideline of the operator's key account manager. Some of the new service ideas have been later implemented to the customer. The project succeeded in enhancing knowledge exchange and learning between the partners.

Cross-case comparison

This chapter provides a cross-case comparison on knowledge creation and exploitation in inter-firm case projects. According to the theoretical framework, both the relational resources and the knowledge-based resources influence knowledge creation. In a more detail, this paper identified the positive and the negative events in the case projects that influenced how well the case projects fulfilled the conditions of knowledge creation and exploitation described in the theoretical framework. This chapter is summarized with the lessons learned on the success factors of collaborative R&D projects.

Knowledge creation

The collaborative R&D projects were initiated either by a close inter-personal relationship or a clear customer need based on which the operator was contacted. The most successful collaborative R&D projects were initiated based on the latter alternative. These collaborative projects were based on a well-scoped customer need that provided a genuine "win-win" situation for all parties involved. This in turn enhanced the anticipation of value among project participants. The anticipation of value could also be increased along the project progress, if both parties felt that the project was proceeding well and the collaboration enhanced their own learning.

The motivation of project participants was high in the case projects in which the participants had joint goals. Moreover, the definition of clear roles and responsibilities between the partners and joint project management practices enhanced the motivation of project participants. Thus, participants felt that the collaboration was beneficial and that it was managed efficiently i.e. participants were not wasting their time in the joint meetings. In the case project Mobility, well-organized joint meetings enhanced idea generation and learning among project participants. They had high motivation to collaborate and even organized joint evenings to celebrate key project milestones.

The combination capability i.e. knowledge integration between partners required that customer requirements were determined in enough detail in order for the operator to get the necessary knowledge for the solution development. Moreover, good project documentation and the joint review of it were necessary in order to avoid misunderstandings between partners. In the case project E-delivery, the customer-oriented and proactive approach of the operator enhanced the combination capability.

For instance, the operator not only provided user guidelines, but also consulted the customer in the implementation of related processes that enabled the customer to utilize the new solution efficiently.

In regard to the knowledge characteristics, the quality and the fit of knowledge-based resources between partners were important. Partners needed to have excellent, complementary knowledge bases, being specialists in their own fields, in order to provide novel and nonredundant knowledge to each other. In the case project E-transaction, direct links between specialists in partnering firms were initiated, which was crucial in the project success. The knowledge heterogeneity was created through the integration of market-technical knowledge. This ensured the fit of the new service concept with market requirements. Table 2 presents a cross-case comparison on the factors that influenced the knowledge creation in the case projects.

Table 2 Knowledge creation in case projects

	Case: Mobility	Case: Multi-access	Case: E-delivery	Case: E-transaction	Case: Communications
Access to parties	<ul style="list-style-type: none"> • Long existing customer relationship • Based on a close relationship between two persons 	<ul style="list-style-type: none"> • Has been a customer earlier • Based on a close relationship between two persons 	<ul style="list-style-type: none"> • Existing customer relationship • Customer contacted the operator to solve a concrete need 	<ul style="list-style-type: none"> • Existing customer relationship • Customer contacted the operator to solve a concrete need 	<ul style="list-style-type: none"> • Long existing customer relationship • Based on a close customer-operator relationship
Anticipation of value	<ul style="list-style-type: none"> • Increased step-by-step as both parties felt that the project was progressing well. 	<ul style="list-style-type: none"> • High among project managers that shared the same future vision, low among others. 	<ul style="list-style-type: none"> • High – a genuine win-win situation. • Well-focused scope 	<ul style="list-style-type: none"> • High – a genuine win-win situation. • Well-focused scope 	<ul style="list-style-type: none"> • High – a genuine win-win situation • Wide scope
Motivation	<ul style="list-style-type: none"> • High - clear goals and good project management: Good planning, light organization, efficient meetings, results documented. 	<ul style="list-style-type: none"> • Low - participants had conflicting views, some directly opposed joint cooperation. • Different project practices 	<ul style="list-style-type: none"> • High – joint goals, clear roles and responsibilities, good project management 	<ul style="list-style-type: none"> • High – joint success criteria, clear roles and responsibilities, top management commitment and support 	<ul style="list-style-type: none"> • High – clear roles and responsibilities, good project management, cooperation was seen important by all participants
Combination capability	<ul style="list-style-type: none"> • High – partners had both strong technical knowledge bases. • Customer explained well its requirements. Joint review session brought new ideas. 	<ul style="list-style-type: none"> • Low - customer was not able to explain its requirements in enough detail. Partners did not have enough time to review them jointly. 	<ul style="list-style-type: none"> • High – operator was customer-oriented and proactive in consulting the customer and its stakeholders. 	<ul style="list-style-type: none"> • High – direct links created between specialists that had strong technical, knowledge bases. • Common project terminology defined 	<ul style="list-style-type: none"> • Quite high – although in a few sub-projects customer was not able to explain its requirements in enough detail
Novel and nonredundant knowledge	<ul style="list-style-type: none"> • All partners with specialist knowledge (new to others) 	<ul style="list-style-type: none"> • Partly novel and useful knowledge, but sometimes not detailed enough. 	<ul style="list-style-type: none"> • All partners with specialist knowledge (new to others) 	<ul style="list-style-type: none"> • All partners with specialist knowledge (new to others) 	<ul style="list-style-type: none"> • Partly novel and useful knowledge, but sometimes not detailed enough.
Knowledge heterogeneity	<ul style="list-style-type: none"> • Complementing technical knowledge bases. Also business insight brought to the project. 	<ul style="list-style-type: none"> • Partly complementing technical knowledge bases. Knowledge on business operations missing. 	<ul style="list-style-type: none"> • Complementing market-technical knowledge bases. 	<ul style="list-style-type: none"> • Complementing market-technical knowledge bases. 	<ul style="list-style-type: none"> • Complementing technical knowledge bases. A few sub-projects left without knowledge on business operations.

Knowledge exploitation

The most important success criteria that determined whether knowledge exploitation occurred or not in the case projects, was the business viability of the new service concept. This is why it was very important that market knowledge and business insight was incorporated in collaborative R&D projects. In the case project Mobility, the knowledge creation itself was successful, but the project ended as a failure, because the commercialization of the new service was postponed. The reason for this was that the business potential seemed too weak for the operator. The operator should have clarified this issue before the project initiation. In the case project Multi-access, the customer perceived the new solution too expensive and not to fit with its changed business focus. The communication and trust between the partners was weak during the whole project, although some improvements were made during the project progress. The case project Communications was successful as some knowledge exploitation occurred based on it. However, it would have been even more successful, if the customer had been able to provide knowledge on its business processes in all sub-projects.

All successful case projects fulfilled the criteria of business viability and ended in knowledge exploitation. The collaboration between partners continued after the project was finished. In the case E-delivery, the customer-oriented approach of the operator supported the project success. The customer purchased the new service concept and later also related services. In the case E-transaction, the top management support and the experienced project management enhanced the project success through helping in difficult situations. The commercialization of the service concept has later started and the collaboration continues.

Some of the case projects were able to improve the likelihood of project success through the re-evaluation and the readjustment of the initial project conditions. This was especially successful in the case project E-delivery. However, as all the case projects enhanced learning and some of them the development of new ideas, it is still possible that competitive advantage will be later created based on all the case projects. Table 3 summarizes the factors made to readjust the initial project conditions and the direct outcome of the case projects.

Table 3 Knowledge exploitation in case projects

	Case: Mobility	Case: Multi-access	Case: E-delivery	Case: E-transaction	Case: Communications
Continuous learning, re-evaluation and readjustment of the initial conditions.	<ul style="list-style-type: none"> • Project failed to clarify the business viability for the operator, despite successful inter-firm interaction → joint idea sessions brought many new ideas during the project 	<ul style="list-style-type: none"> • Trust and communication between partners remained weak, despite improvements → one person replaced, project scope narrowed, additional time given 	<ul style="list-style-type: none"> • Customer-oriented approach of the operator supported the project success. → proactive communication to all stakeholders, preparing additional guidelines 	<ul style="list-style-type: none"> • Top management support and the experience project management helped to solve difficult situations. → enabled the testing of a new solution in operator network etc. 	<ul style="list-style-type: none"> • Customer was not able to provide market knowledge in some of the sub-projects. Thus, some of project results were too general and they were not realized.
Direct outcome	<ul style="list-style-type: none"> • Failure. The commercialization postponed as the business potential seemed too weak for the operator. • Enhanced learning, many new ideas developed. 	<ul style="list-style-type: none"> • Failure. The product was not commercialized, as customer perceived it too expensive and not to fit with its changed business focus. • Enhanced learning, many new ideas developed. 	<ul style="list-style-type: none"> • Success. Customer purchased the service concept and also related services. • Enhanced learning, dialogue with the customer continues. 	<ul style="list-style-type: none"> • Success. The commercialization of the service concept started. • Enhanced learning, collaboration continues. 	<ul style="list-style-type: none"> • Success. The joint service development plan developed. The customer has purchased some of the services planned. • Enhanced learning, many new ideas developed.

Lessons learned on success factors

Based on the collaborative case projects, the following lessons can be learned. First of all, it is important that before the initiation of collaborative R&D project an initial business case is prepared in order to ensure that the project is worth executing. Moreover, it is necessary to communicate openly to the customer that it is possible that the new service concept developed together will not be commercialized. This is to overcome the possible disappointment and the following discontinuity of the partnership, if the new service concept is not commercialized.

At the beginning of the joint project, it is important to define the project scope to be narrow enough and to focus on a clear customer need. The long-term successful partnership seemed to depend on whether the partners were able to develop a genuine win-win situation. This type of situation led to additional cooperation and sales after the initial collaborative R&D project was finished. Moreover, the definition of the project stakeholders at the project start supports the identification of the necessary project participants, project communication needs and project risks. The definition of joint goals, joint project practices as well as clear roles and responsibilities between the

partners is also important. This largely influences the project efficiency and the motivation of the partners.

The quality and the fit of knowledge-based resources between the partners were important. If both partners were able to provide their specialized knowledge to each other, this ensured that both project partners were learning and the outcome of the project could not have been developed without the existence of the collaborative R&D project. During the project, the identification of customer requirements is very crucial. They need to be detailed enough, include both market and technical knowledge as well as to be well-documented and reviewed with the customer. In addition, a proactive customer-oriented approach supports the project progress in identifying customer requirements in enough detail and in consulting the customer in the actual service implementation. These enhance the combination capability of partnering firms.

In regard to the project management, this paper indicates it to be important to conduct the project in parallel phases. In this way, the customer requirements, the technical solution development and the feasibility testing can be enhanced iteratively in a continuous interaction between the customer, the operator and the possible other partners. Also, it is wise to reserve time in the delivery process for consulting the customer in the implementation of the new service. The iterative project approach enhances the quality of the final outcome and thus the success of collaborative R&D project for both parties.

DISCUSSION AND CONCLUSIONS

This paper demonstrated collaborative R&D projects in which knowledge creation was based on the integration of specialist knowledge, as proposed by a recent article on the knowledge accessing theory of alliances (Grant and Baden-Fuller, 2004). Whereas prior research on the social network theory and the knowledge-based view have determined the conditions of successful knowledge creation, this paper focused on the process of implementing them in collaborative R&D projects with customers. It contributes to extant theory and practice through an increased understanding on the success factors in knowledge creation and exploitation in collaborative R&D projects. While some of the success factors found in this paper have also been discussed in prior research, this paper

above all contributes to extant theory through demonstrating the link between these success factors and the conditions of successful knowledge creation and exploitation. As managerial implications, this paper provides a list of lessons learned on the success factors of collaborative R&D projects with customers.

First, this paper indicates that the partners' anticipation of value is highest in projects with clear customer need, focused project scope and a genuine "win-win" situation. Second, the motivation of project partners is enhanced with the definition of clear roles and responsibilities between partners and joint project management practices. In regard to project management, structured project meetings and a detailed documentation decreases the likelihood of misunderstandings between partners. Moreover, a parallel project phasing enhances the quality of the project output, as it enables an iterative product development in a continuous interaction between project partners. Third, the identification of detailed customer requirements and the customer-oriented, consulting approach, enhance the combination capability of partners. It is important for the project success that a project manager takes proactively care of project communication and guidance with all stakeholders. Fourth, the partners need to have specialist knowledge, which is complementary and include both market and technical knowledge in order to create novel and heterogeneous knowledge combinations. Fifth, this paper indicated the most critical component in the process of knowledge exploitation to be the business viability of the new service concept. Thus, it is important to make an initial business case before the implementation of the collaborative projects as well as to ensure that business insight is brought into the collaborative R&D project.

The results of this paper cannot yet be generalized to other types of projects, firms, industries and markets without further studies. As such they provide lessons learned on implementing collaborative R&D projects with customers in the telecommunication services industry. Prior research has found inter-firm R&D collaboration to be especially important in such dynamic and technology-intensive industries (Hagedoorn, 2002, Powell *et al.*, 1996). Moreover, the collaboration in the case setting is especially challenging due to the technical complexity and the variety of customer industries. This is why the smooth and the functioning interplay between the partners are highly important in order the knowledge creation and exploitation to be successful in these projects.

I recommend future studies to further examine the implementation challenges of collaborative R&D projects in other types of research settings. This knowledge is important both for the theory and practice of collaborative R&D projects. It also increases the understanding on the generality of the success criteria found in this study.

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