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The role of inter-organizational relationships in the development of patents: a knowledge-based approach

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Abstract

This paper examines the role of various inter-organizational relationships in patent development, and how these relationships contribute to patent competitiveness. It takes the perspective of individual inventors and describes how they utilize external knowledge in the development of patents. Based on a case study of a European telecom operator, we found interaction with R&D consortia, suppliers and customers to support inventors in the development of new ideas for patents and in solving related problems. In terms of patent competitiveness, buyer-seller relationships were more valuable for an operator than R&D consortia relationships, as they reduced the market and technology uncertainty related to the patent.

Keywords: Inter-organizational relationships; Inventor; Knowledge; Patent; Telecommunications

1. Introduction

Knowledge has been widely recognized as a source of organizational competitiveness (Grant, 1996; Nonaka and Takeuchi, 1995; Spender, 1996). Prior research has found that inter-organizational relationships support the exchange and subsequent creation of knowledge (Galunic and Rodan, 1998; Kogut and Zander, 1992). So far, the emphasis in the study of knowledge as a basis of competitive advantage has

been on organizations as collective constructs rather than on the level of individual action and interactions (Argote and Ingram, 2000; Felin and Foss, 2006). This paper examines how the inventors of patents search for and utilize external knowledge in the development process, and how this contributes to patent competitiveness. The main objective is to increase current understanding about the role of inter-organizational relationships in the development of patents through studying the perspective of individual inventors.

Our focus is especially on the patenting process, and not on innovations or organizational innovativeness more generally. There are many quantitative studies demonstrating a link between inter-organizational relationships and the number of patents (e.g., Ahuja, 2000; Dutta and Weiss, 1997; Shan et al., 1994; Stuart, 2000), but few case studies exploring this relationship in detail. Moreover, success in patenting does not necessarily correspond to success in translating patents into competitive advantage (Spender and Grant, 1996), which it is important to study patent quality as well. The primary research data for the study was collected from the inventors of case-company patents through a survey and face-to-face interviews. This type of methodology enabled the collection of rich, qualitative data.

The paper is organized as follows. First, it gives a brief theoretical overview of the knowledge-based view of the firm and of previous empirical research on inter-organizational relationships and patenting. Secondly, it describes the research method and the data used in the empirical study, and then presents the results. Fourthly, the theoretical and managerial implications are discussed, and finally the limitations of the study are considered and directions for future research suggested.

2. Theoretical background

2.1. The knowledge-based view of the firm

The knowledge-based view (KBV) of the firm addresses issues concerning the existence, the boundaries, and the internal organization of the multi-person firm (Foss, 1996). It emphasizes knowledge as a strategic resource and a source of competitive advantage (Grant, 1996; Kogut and Zander, 1992; Nonaka and Takeuchi, 1995; Spender, 1996). According to the KBV, performance differences between organizations accrue due to their different stocks of knowledge and their differing capabilities

concerning its use and development. Competitive advantage, in fact, flows not from resources themselves but from how they are used for productive purposes (e.g., Penrose, 1959; Kogut and Zander, 1992; Grant and Spender, 1996; Grant, 1996).

Collective knowledge consisting of patterns and modes of combined knowledge among individuals, groups, units and organizations is the most secure and strategically significant kind of organizational knowledge (Conner and Prahalad, 1996). Given that knowledge is dispersed and specialized, and due to human bounded rationality, individuals cannot resolve complex issues by themselves. The integration and coordination of knowledge are key mechanisms of the knowledge-based firm (Grant, 1996; Tsoukas, 1996; Spender and Scherer, 2007).

Previous studies have presented organizational knowledge creation as an evolutionary cyclical process that starts from the combination of external stimuli (competitors' initiatives, normative changes, scientific discoveries) with internally generated information (Nonaka and Takeuchi, 1995; Zollo and Winter, 2002). Individuals in organizations that interact with external stakeholders thus ultimately initiate the creation of organizational knowledge. These individuals are the primary source of knowledge and its transfer, and thus studying knowledge on the level of individual interactions could potentially bring important new information to existing organization-level explanations on knowledge creation (Argote and Ingram, 2000; Felin and Foss, 2006).

2.2. A classification of inter-organizational relationships

Prior literature has often classified inter-organizational relationships according to the motive, the relatedness, and the governance form. Primary motives for forming inter-organizational ties fall into three areas - enhancing market position, lowering transaction costs, and learning (Kogut, 1988). The relatedness may be horizontal or vertical. Horizontal ties are formed among actors engaging in the same strategic activities and typically feature cooperation with competitors and peers, while vertical ties relate to buyer-seller relationships and involve suppliers and customers (Harrigan, 1988).

The governance form depends on appropriation concerns and the coordination costs related to inter-organizational collaboration (Gulati and Singh 1998). The greater the

concerns and the higher the costs, the more hierarchical the chosen structure is likely to be. Van den Ende (2003) demonstrated that high market and technological uncertainty creates transaction costs in the development of mobile networks due to the number of redesigns and related increased communication needs between partnering firms. He argues that internal development is the appropriate choice for a telecom operator in the fluid phase with high market and technological uncertainty, while different forms of cooperation between the operator and the service firm are appropriate in other phases with low levels of uncertainty in one or both areas.

Joint ventures are the most hierarchical governance modes, followed by strategic alliances based on contractual agreements. Strategic alliances could be defined as "agreements characterized by the commitment of two or more firms to reach a common goal entailing the pooling of their resources and activities" (Teece, 1992). There are many inter-organizational relationships that are not based on common goals or collaboration agreements, however, such as close working relationships with suppliers and customers, and cooperation in the form of R&D consortia (Tidd et al., 1997).

2.3. The role of inter-organizational relationships in the development of patents

Early literature on innovation management suggests that external knowledge is especially important in the *idea-generation* phase of the innovation process, which involves the generation of the initial design concept, and that internal communication between the different functional areas is essential in the *problem-solving* phase, which requires technical efforts at solution development (Tushman, 1977). Recent literature on "open innovation" has further emphasized the importance of inter-organizational relationships in the innovation process. According to Chesbrough (2003), the role of internal R&D is to identify, understand, select from, and connect to the wealth of available external knowledge, and to fill in the missing pieces of knowledge that is not being externally developed.

Prior research has shown that strategic alliances and partnerships enhance innovativeness, measured in terms of the number of patents (Ahuja, 2000; Dutta and Weiss, 1997; Shan et al., 1994; Stuart, 2000). There are several weaknesses in merely using patent counts to measure innovation performance, however (Griliches, 1990)[i]. The focus of the studies has been on examining strategic alliances and partnerships in the patenting context. Among the few researchers considering other relationships as well,

Rominj and Albaladejo (2002) found in a survey of 33 small software-development and electronics manufacturing companies in the U.K that only the interaction with R&D institutions and service providers increased the rate of patenting. While customers, suppliers, vendors and universities have been identified as important sources of innovation (Trott, 2002; Tidd et al., 1997; Tushman, 1977; Utterback, 1971; von Hippel, 1988), the role of these interfaces in the development of patents has been studied very little.

Given the numerous studies on the impact of alliances on a firm's patenting rate, it would be natural to assume that their wide use would lead to joint patenting by the partnering companies. However, no evidence of this type of relationship was found in a recent study conducted by Hagedoorn et al. (2003), in which the authors compared jointly-owned U.S. patents filed in 1989-1998 with the MERIT-CATI database on R&D alliances. They concluded that while formal R&D partnerships, such as joint ventures and R&D pacts, may generate several benefits, they do not contribute to the sharing of intellectual property rights through joint patenting. In fact, they suggest that firms try to avoid joint patenting if possible, because property rights in co-owned patents remain partial.

In sum, earlier research has widely demonstrated that inter-organizational relationships positively influence the number of patents. However, there are few micro-level studies examining the role of various inter-organizational relationships in patent development on the level of individual interactions, and how these relationships contribute to patent competitiveness.

3. Methods and Data

3.1 Methodology

The research reported in this paper was based on the case-study approach, which is a typical method when the focus is on the knowledge-based view (Hoskisson et al., 1999). It is also well suited for rarely researched phenomena in that it enables the collection of rich and detailed process data (Eisenhardt, 1989; Voss et al., 2002). It also facilitates the generation of novel, precise, and empirically valid theories, although a weakness is that it provides only narrow and idiosyncratic results (Eisenhardt, 1989).

Data triangulation was used in order to produce a rich understanding of the role of inter-organizational relationships in the patenting process and in the quality of the patents. First, face-to-face interviews with the inventors were used as a primary data source on the role of inter-organizational relationships in the development of the case-company patents. Secondly, we conducted a survey in order to statistically evaluate how widely such relationships were utilized and what influence they had on patent competitiveness. We then carried out several expert interviews with the case-company R&D managers and patent engineers in order to shed light on the patenting policies and the process of patent development in general.

3.2. Data collection and analysis

The case company is a European telecom operator with a reputation for being innovative. It was chosen as a research target because it was known to be active in R&D. It is a leading operator in its national market, with annual revenues of approximately €2,100 million over the research period of 1996-2004. Its R&D intensity (annual R&D expenditure divided by annual revenue) was 3.4% in the research period, which is high compared to other major telecom operators[iii]. The company has a long history of innovations, including the launch of NMT (Nordic Mobile Telephone), the world's first multinational cellular system, in 1981.

The intellectual property rights (IPR) unit of the case company provided secondary data on its patents, including a list of 209 patents and patent applications filed between January 1996 and March 2004. This list featured the names of the inventors of the patents, the date of the application, the current status (granted or pending), and a short description of the object of the application.

The first step in the research was to set up interviews with inventors of the case company's patents. Experienced inventors who had developed several patents were invited to take part in these interviews, the main purpose of which was to clarify from whom and how inventors typically seek and utilize external knowledge in the development of patents. This research concerned all kinds of contributory external stimuli, from informal and infrequent firm-external interactions all the way to possible alliance and joint-venture relationships. The questions asked in the interviews were the following: "What were the most important inputs gained from external bodies in the

development of patents?" "What were these external bodies and what was the input gained from them?"

The interviews were semi-structured in order to facilitate the collection of comparable data, and also to leave room for additional questions that seemed fruitful to pursue during the course of the interview. A total of 13 one-hour interviews covering 72 case-company patents or patent applications were conducted in 2004-2005. The interview responses were analyzed in terms of the similarities and differences identified in the examined patent-development processes. Direct quotations were utilized when they were illustrative of the key findings on the common mechanisms of searching for and utilizing external knowledge in the development of patents and of their related benefits.

Secondly, the complementary survey questionnaire was developed in order to quantify the role of inter-organizational relationships in the development process. It included the following questions: "What internal and external contacts enhanced the development of patents?" and "How frequent was your interaction with these internal or external contacts?" Patent competitiveness was assessed according to four subjective performance measures, which were based on Barney's (1997) characteristics of competitive advantage: how valuable, rare, and costly-to-imitate the patents were, and how the firm could exploit them based on its existing resources. The questions on patent competitiveness are presented in Table 1. The inventors evaluated these performance-related questions on a five-point Likert scale on which number five corresponded to "strongly agree" and number one to "strongly disagree".

[Insert Table 1 about here]

The survey was reviewed with the case-company R&D managers before it was sent to the inventors in order to ensure content validity. In addition, we tested the reviewed questionnaire with two inventors in order to detect possible sources of misunderstanding. The questionnaire was sent in December 2004 to all the inventors of patents employed by the case company at that time (106 inventors). The survey covered the processes behind the most recent case-company patents in 2002-2004 in more detail than the earlier processes in 1996-2001, mainly because several of the inventors no longer worked for the company. A total of 28 inventors responded to the survey, and the responses covered 90 patent-development processes, i.e. 43% of the total of 209 patents. Six of the inventors who responded to the survey agreed to be interviewed, which meant

that one third of the patents covered in the survey were also included in the interview sample. To conclude, the survey sample was able to cover a larger number of inventors than the interview sample, while the difference in the number of patents covered is not as large. Table 2 presents the case-company patent portfolio in relation to the interview and survey samples.

[Insert Table 2 about here]

The different patent-development processes were compared in the analysis of the survey responses. In terms of competitiveness, the patents involving the acquisition of external knowledge (from R&D consortia or buyer-seller relations) were compared with those based on only internal knowledge. An ANOVA test was performed in order to compare these three groups of responses in terms of their mean value, at a 95% confidence interval for the mean and standard deviation.

4. Results

4.1. A brief description of patent development in the case company

The case company developed a total of 209 patents, most of which were national, in the period January 1996 - March 2004. This was an average of 25 patents in a year, while during the telecom boom in 1999-2000 it developed over 40 patents in one year. During that time the R&D personnel were especially encouraged to generate patents with a view to strengthening the innovative image of the company and sowing seeds for the emergence of new communications services. The inventors were 32 years old on average, and had held their jobs for an average of five years. Most of them were male (89%), and had a Master of Science degree (86%).

The patent-development process in the case company typically starts when an employee finds a problem when working in an R&D consortium, or comes up with a new service idea when involved in an internal R&D project. This phase is referred to as the idea-generation phase in this study. Typically, the employee then discusses the problem (or the idea) with colleagues, who then start to solve the problem (or to develop the idea further) on the basis of their internal and possibly also external knowledge. This phase, which is referred to as problem solving in this study, ends when the employee submits an internal invention report in which he/she describes the new solution. We did not examine the work of the patent engineer, or of the patent board,

which makes the final decision on whether the company will apply for a patent based on the suggested new solution.

According to the IPR management in the case company, an operator faces several challenges in exploiting patents. First, it is difficult to protect a service idea through patenting because there are multiple technical options for implementing an operator service. Secondly, as the telecom operator does not manufacture or design telecom networks and end-user equipment, it has more limited capabilities in terms of exploiting technical patents than equipment manufacturers. It typically needs an external company to support the technical implementation of the underlying service opportunities.

4.2. The role of inter-organizational relationships in the development of patents

4.2.1. The motive, the relatedness and the governance form

This section presents the generic findings of the interviews with regard to the kind of inter-organizational relationships the inventors utilized in the development of patents, and why they used them. The following two sub-sections, which are also based on interview data, describe in more detail how the inventors interacted in practice with external parties in the two first phases of the patent-development process – idea generation and problem solving.

The inventors acquired their external knowledge through their inter-organizational relationships in nearly half of the 72 patent-development processes examined. The key motivation for acquiring the knowledge in all of these cases was in order to learn. The most common sources of external knowledge were R&D consortia, and vertical supplier and customer relationships. A horizontal relationship featured in only one patent-development process, which benefited from the knowledge of a partner telecom operator. External knowledge was helpful in terms of generating new ideas for patents. In the problem-solving phase the inventors actively sought technical knowledge from R&D consortia on new technologies, and from suppliers on their products.

Knowledge search from external sources was typically infrequent and informal, and the knowledge was acquired in the context of close working relationships rather than contract-based partnerships such as joint ventures and alliances. New knowledge creation in the development of patents was always kept within the firm. In all of the processes the inventors combined their acquired external knowledge with their internal

knowledge, and the resulting knowledge was never transferred outside the company before the patent application was filed. The inventors emphasized that new knowledge should be kept internal until the intellectual property rights are established. Thus, the governance mode in the development of patents was typically internal. The role of inter-organizational relationships was to support the telecom operator's internal development in the form of external knowledge acquisition.

4.2.2. Inter-organizational relationships in the idea-generation phase

The R&D consortia and the supplier/vendor relationships were the most common sources of external knowledge in the idea-generation phase. The patents that incorporated R&D consortia knowledge typically supported the development of next-generation technologies, which were at the standardization stage. The employees involved in the consortia meetings were from the research unit of the case company. The consortia provided them with detailed knowledge in a certain technology area. All the interviewees who had utilized this knowledge in the development of patents considered their participation in R&D consortia necessary in that it enabled them to detect problems in their existing knowledge base and to contribute to their resolution with new knowledge. One inventor explained this general finding on the role of standardization-oriented R&D consortia well:

> *"Standardization work is an important tool for developing patents and networking externally. But one does not get ideas directly from working in a standardization body. One must invent him/herself the suggestions for enhancing existing knowledge".*

The patents that involved supplier or vendor knowledge were typically related to incremental improvements in existing services and technologies. On several occasions, inventors had come up with a new service-development idea while listening to an external presentation by a supplier/vendor, and in one case a partner telecom operator. Customer and university relationships also supported the idea generation. Customer requests provided ideas for new service development, while university collaboration contributed with ideas for new research directions. Table 3 describes how the inventors typically acquired external knowledge in the case company, and gives examples of how their inter-organizational relationships supported idea generation.

[Insert Table 3 about here]

4.2.3. Inter-organizational relationships in the problem-solving phase

R&D consortia and supplier/vendor knowledge were also the most common external sources of knowledge in the problem-solving phase. According to the inventors, the detailed knowledge about existing standards or supplier/vendor products supported the development of the technical solution underlying the patent idea. The solution that formed the basis for the patent was developed internally by a group of inventors, typically from different company functions such as research, products and services, and network operations.

The patents that utilized customer knowledge described a technical solution behind an immediate customer need. They were developed in cooperation between sales and marketing, products and services, and the research unit. The customer knowledge was important in that it ensured that the new solution was compatible with customer needs. One inventor described its value as follows:

> *"Without customer discussions we would have started the solution development from a technical perspective. At the end, we would have come up with an excellent technical solution, which would have been too advanced and thus too expensive for the customer."*

Another inventor added:

> *"The knowledge about the customer's technical environment was necessary for us to develop a functioning solution, which could be realized with small additional investments by the customer and by us".*

Table 4 describes how the case-company inventors typically utilized external knowledge for problem solving, and gives examples of how inter-organizational relationships supported the problem solving in the company.

[Insert Table 4 about here]

4.3. The impact of inter-organizational relationships on patent competitiveness

This section presents the findings from the survey of 90 patent-development processes in the case company between January 1996 and March 2004. The inventors utilized inter-organizational relationships in their knowledge acquisition in 39% of these processes. In 21 of them they utilized R&D consortia knowledge, and in 13 they utilized

supplier, vendor, or customer knowledge. One process benefited from university knowledge. In 55 cases the inventors did not utilize external knowledge at all.

The survey also revealed that external knowledge acquisition from inter-organizational relationships was infrequent: the inventors interacted with R&D consortia members once every second month on average, and with suppliers once a month on average.

Table 5 lists the patent-development processes divided into three groups based on the source of knowledge used: R&D consortia, buyer-seller relationship, and exclusively internal knowledge. As there was only one process that benefited from university knowledge, it is not included in the groups. The table illustrates how the inter-organizational relationships contributed to the competitiveness of the patents through a comparison of the average outcome ratings of the survey respondents among the above-mentioned three groups. An ANOVA was performed in order to compare these three groups of responses in terms of mean value, the 95% confidence interval for the mean (95% CI for mean), and the standard deviation (std. dev.).

[Insert Table 5 about here]

The patent-development processes in which the inventors interacted with suppliers, vendors or customers gave the highest mean values with regard to three of the four measures of competitiveness, and the highest-value levels according to the 95% confidence interval for the mean. This result does not imply that all of these patents were more competitive than other patents. It rather indicates that external knowledge acquisition from vertical relationships potentially enhances the competitiveness of patents, but it does not automatically do so. Interaction with customers potentially ensures that there will be customer demand for the service opportunity underlying the patent, and interaction with suppliers and vendors that it will be possible to implement the patented solution.

Table 5 further demonstrates that the differences between the groups were statistically significant with regard to three measures. The patents that benefited from R&D consortia relationships were found to be less valuable (p=0.0007) and less rare (p=0.020) than other patents. On the other hand, those benefiting only from internal knowledge were related to having good internal resources for exploitation, whereas R&D consortia did not (p=0.0032). There were no significant differences between the

groups in terms of the difficulty and cost of imitation. The patents based on R&D consortia knowledge typically involved next-generation technologies, which may have limited the case company's ability to exploit them: being in the service sector, it is dependent on its suppliers and vendors to implement the needed hardware.

5. Discussion and conclusions

This paper contributes to the knowledge-based view of the firm through the analysis of external knowledge acquisition on the level of individual interactions. We have described how inventors search for and utilize external knowledge in different phases of patent development. We found informal and infrequent inter-organizational relationships that could be described as close working relations to be the main source of external knowledge, and not formal partnerships based on contractual agreements. This knowledge contributes to the generation of new ideas for patents and in solving of related problems. According to our study results, the new knowledge is being created firm-internally in the context of patenting. Knowledge appropriability has clearly been an issue in the development of technology-enabled services, in which the protection provided by legal mechanisms is weak and imitation is rather easy. This is in line with earlier findings showing that inter-organizational relationships are used for knowledge acquisition rather than for collaborative knowledge creation in the context of patenting (Hagedoorn, 2003; Hagedoorn et al., 2003).

Moreover, we have demonstrated the impact of inter-organizational relationships on patent competitiveness. This suggests that buyer-seller relationships are more valuable to an operator than R&D consortia relationships in terms of patent competitiveness, as they have the potential to reduce the market and technology uncertainty related to the patent. Moreover, we found that patents based on next-generation technology in which inventors utilize R&D consortia knowledge are most difficult for an operator to exploit given its current internal resources. While prior research has extensively demonstrated the benefits of external collaboration in quantitative terms of increased patenting activity, this paper takes an initial step in evaluating the qualitative benefits associated with external knowledge utilization.

In terms of managerial practice, we would emphasize the importance of external stakeholder meetings as learning events. There is a strong need for continuous dialogue

with customers and suppliers at all organizational levels. The knowledge that resides in these contacts could thereby be used to generate new innovative ideas and to lower market and technology uncertainty related with the new technical solution.

The major limitation of this study is its focus on one case company. Although the research covered a large number of patent-development processes, the results cannot be generalized to other industries or types of firm. The role of patents is typically minor in the service sector compared to manufacturing companies (Hipp and Grupp, 2005). It is therefore likely that the benefit of R&D consortia relationships and patents based on next-generation technologies will be higher for manufacturing companies than for service companies. The firm size also influences the use of inter-organizational relationships and collaboration.

Another limitation concerns how the competitiveness of patents was measured. It was based on self-reported data from the inventors of the case-company patents, and thus was subjective in nature. In this case this was the only alternative: the company's IPR management does not evaluate patent competitiveness, and insists that the inventors are the only people in the company who fully understand the exploitation potential. Moreover, the results can only give early indications on the subject of patent competitiveness given the small sample size in each category group. Future research is needed in order to improve the measurement of patent quality, and thus to get away from the overwhelming focus on quantity.

Further research is also needed in different kinds of industries and companies on how firm-external knowledge is used for value creation in the development of patents. A promising approach is to analyze fewer patent-development processes and to take a closer look at the underlying knowledge-exchange processes, and at the roles and dynamics of tacit and explicit knowledge in knowledge transfer. This type of research would contribute to the knowledge-based view through enhancing understanding of the nature and role of inter-organizational knowledge-exchange processes in the context of patenting.

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Table 1 Survey measurement on the competitiveness of patents

Patent Competitiveness : Please choose the alternative for each statement that best characterizes the competitive advantage related to your patent at the date of application. (5=strongly agree, 4=agree, 3=somewhat agree, 2=disagree, 1=strongly disagree.)
• This patent is very valuable as it enables our company to respond to the market opportunity or threat
• This patent is based on knowledge with which our competitors are not familiar
• The service idea related to this patent is very difficult and costly for our competitors to imitate
• Our company has good resources for exploiting this opportunity

Table 2 The case company's patent portfolio in relation to the interview and survey sample

Case company patent portfolio	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**Q1/ 2004**	**Total**
Number of patents	11	17	25	19	41	44	27	21	4	209
Number of inventors per patent	2.3	1.8	2.4	1.7	2.1	2.1	2.0	1.9	2.0	2.0
Interview sample	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**Q1/ 2004**	**Total**
Number of patents	1	0	7	4	17	22	10	11	0	72
Number of inventors per patent	2	0	2.3	2.8	2.1	3.1	2.6	2.5	0	2.5
Survey sample	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**Q1/ 2004**	**Total**
Number of patents	3	2	1	2	18	26	19	17	2	90
Number of inventors per patent	2	4	3	2	2.5	2.4	2	2.6	2.5	2.4

Table 3 External knowledge utilization in the idea-generation phase

Source of external knowledge	Brief description of external knowledge utilization	Examples
▪ R&D consortia	▪ Participation in R&D consortia meetings often provided a stimulus for a new idea. The meetings enabled the participants to follow-up some technology development in detail, which enabled them to detect gaps in existing knowledge.	▪ The case-company participant found out that a standard in its current form could not resolve an important issue. He started to work with a group of R&D colleagues to provide a solution.
▪ Supplier / vendor	▪ Participation in a supplier/vendor presentation, which focused on future products and product development, supported idea generation.	▪ The case-company employee was listening to a vendor presentation. He had an idea to implement a similar functionality in another technology environment. The solution was patented.
▪ Customer	▪ Customers commonly contacted the case company when they needed new types of services, or to add new functionalities to existing services.	▪ The case-company employee received a request from a customer to add a new functionality to an existing service. He contacted one of the company's technical specialists to find a solution. This solution was patented.
▪ University	▪ The university relationship gave ideas for a new research direction.	▪ The university was involved in launching a research project with the case company. The case-company employees started to consider one of the topics in an internal project, which resulted in the creation of two patents.
▪ Partner telecom operator	▪ Attendance at a presentation given by a foreign partner telecom operator, which focused on new services, gave a stimulus for a new idea.	▪ The case-company employee visiting the partner had the idea to develop a new solution with a functionality that was similar to the one the partner demonstrated. This new solution was developed for another technology environment in the case company's domestic market. The solution was patented.

Table 4 External knowledge utilization in the problem-solving phase

Source of external knowledge	Brief description of external knowledge utilization	Examples
▪ R&D consortia	▪ Participation in R&D consortia meetings motivated the inventors to examine a technology area in detail. This knowledge supported the development of solutions for filling detected gaps in the current knowledge base.	▪ In one process detailed knowledge of electronic payment technologies acquired from the R&D consortia encouraged inventors to apply this knowledge in a novel way in the patented solution.
▪ Supplier / vendor	▪ Direct contacts (by phone, e-mail, appointment). Technical product knowledge was necessary for the inventors to develop solutions to problems in existing services or for new customer requirements.	▪ In one case detailed information from cash-register vendors provided the case-company employee with important knowledge about currently used technologies. This knowledge was needed to ensure that the new service solution would fit with the current technological environment of the customer, and that it could be implemented with the lowest possible additional investments.
▪ Customer	▪ Case-company employees held discussions with customers in order to find out their requirements for the new solutions, or the customer directly contacted the telecom operator to inform it about its development needs.	▪ Customer input was needed concerning which functionality was essential. The case-company employee contacted the customer directly to ensure that the new service solution would respond to the need.

Table 5 The impact of inter-organizational relationships on patent competitiveness

Patent Competitiveness	**R&D consortia knowledge** *(21 patents)*	**Supplier, vendor or customer knowledge** *(13 patents)*	**Only internal knowledge** *(55 patents)*
Valuable	Mean: 2.7 95% CI for mean: 2.2-3.1 Std. Dev.: 0.7	Mean: 3.8 95% CI for mean: 3.3-4.4 Std. Dev.: 1.1	Mean: 3.6 95% CI for mean: 3.3-3.8 Std. Dev.: 1.1
	F (Sig.) = 7.868 (0.0007)		
Rare	Mean: 2.4 95% CI for mean: 2.0-2.9 Std. Dev.: 0.7	Mean: 3.4 95% CI for mean: 2.8-4.0 Std. Dev.: 1.3	Mean: 3.1 95% CI for mean: 2.8-3.4 Std. Dev.: 1.1
	F (Sig.) = 4.070 (0.020)		
Difficult and costly to imitate	Mean: 2.4 95% CI for mean: 2.0-2.7 Std. Dev.: 0.5	Mean: 2.9 95% CI for mean: 2.4-3.4 Std. Dev.: 1.0	Mean: 2.8 95% CI for mean: 2.5-3.0 Std. Dev.: 0.9
	F (Sig.) = 2.092 (0.13)		
Good internal exploitation resources	Mean: 2.7 95% CI for mean: 2.3-3.2 Std. Dev.: 0.9	Mean: 3.5 95% CI for mean: 3.0-4.1 Std. Dev.: 1.0	Mean: 3.7 95% CI for mean: 3.4-3.9 Std. Dev.: 1.1
	F (Sig.) = 6. 155 (0.0032)		

[i] Patents differ considerably with regard to their quality. See Griliches (1990) for more information on the weaknesses in using patent counts as a measure of innovativeness.

[ii] According to the annual reports, the average R&D intensity of NTT DoCoMo in the same period was 2.1 %, while the average R&D intensity of Deutsche Telecom was 1.7% and Vodafone 0.6 % in the period 1998-2002.