INTEGRATING KNOWLEDGE GENERATED IN A DISTRIBUTED PRODUCT DEVELOPMENT PROCESS
-
CASE STUDIES IN MANUFACTURING SMES

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ABSTRACT

The objective of the present study is to investigate how different types of knowledge, generated in product development in an alliance context, are integrated to the individual firm. Knowledge is categorized as thematic knowledge, process knowledge, and general knowledge. Knowledge sharing is categorized according to level of involvement. Results indicate a very high representation of impersonal knowledge sharing (server or documents), even if there is a high degree of belief among the respondents that personal meetings and continuous knowledge sharing would be better. The present study uses a case study approach in three medium sized manufacturing firms.

INTRODUCTION

Less than half of European firms (44%) had an active innovation operation according to European Union definition during the period 1998-2001 (Eurostat, 2004). As the firms with an active innovations operation produced 75% of the total turn over and employed 72% of the employees in the same population, we can conclude the importance of innovation (Eurostat, 2004).

Research has indicated that small and medium sized firms (SMEs) play an important role for innovation and the growth of the economy. However, in order to compete on a global market, most SMEs are bound to work in alliances to gather enough knowledge and resources for product and technology development, or to be able be active on a larger market. To maximize the effects of knowledge developed the issue of sharing and integrating knowledge is important.

To yield an advantage from technology development, the knowledge must be captured, interpreted and deployed effectively (Grant, 1997). Hamel and Prahalad (1990) refer to this process as integration as “the firm recognizes what it has learned and decides how to use it”. Knowledge integration is needed for information and skills gained from alliance activities as components of the activities that guide the firm’s future actions (Teece et al., 1997). Some of this knowledge is tacit (Polyani, 1983), making it difficult to use, unless integrated into the firm's operations. Managers are often unaware of what knowledge has been gained from alliance activities (i.e. product development).

The acquisition of technological learning does not translate automatically into strong competitive market positions or high performance (McGrath et al., 1995). Integration helps managers to develop shared learning and accumulate knowledge over time (i.e.

Teece et al., 1997). Integration enables the firm to internalize the knowledge gained from its alliance work.

The present study addresses knowledge integration connected to the knowledge generated in product development processes. The setting of the study is a context of medium sized firms and their distributed product development processes.

This study's context

Alliances can be formed with different types of actors (i.e. suppliers, costumers, agents, universities, consultancies), and in these alliances information and knowledge is gathered and created. Inter-firm alliances require at least two partners, though a growing number of co-operations involve more than two partners. Four conditions must be met for a true inter-firm alliance (Jolly, 2004):

- All of the partners in the alliance must accept that they are losing some of their autonomy. This in order to pursue common goals.
- All of the partners have to put aside some of their own resources for co-operation to take effect.
- The alliance activity should produce results that would not have occurred in the context of each running independent activities.
- Outside of alliance activities, each partner should be autonomous and take autonomous decisions.

The NPD projects of this study are all conducted in an alliance context according to above. That is, the projects have been joint efforts with potential profits for mutually and for the individual partners. Each partner is definitely able to take autonomous decisions as they are equally strong and participate in the alliance only because they have a interest in it.

The alliance concept is one example of organizational modes for co-operation. Chiesa et al. (2000) offered taxonomy of the most common forms, defining alliance as "*a company shares technological resources with other companies in order to achieve a common objective of technological innovation (without equity involvement)*". Alliances, as Chiesa define it, are close to *joint R&D, R&D contracts* and *outsourcing* regarding dimensions as control and formalization.

The context of the present study is firms using distributed product development. According to the Aberdeen Group's Global Product Design Benchmark Report, today's products are increasingly brought to market by cross-enterprise teams that span multiple geographic borders (Aberdeen Group, 2005).

When product development is executed by alliances, additional communications, collaboration and control challenges will affect an already complex process. Distributed product development is defined by the Product and Development Management Association (PDMA) as follows (Kahn et al Eds., 2005): "*The separation and optimization of activities performed during a single product development process (i.e., product ideation, development and launch) across multiple geographic locations. These locations may be within a single corporate entity, within subsidiaries or involve the use of third parties.*"

According to PDMA's definition all the cases of the study involve third parties. This helps to draw stronger conclusions in the third party context, but takes away the chance of comparing the three types of distributed product development.

The unit of analysis

Information is defined by Kogut & Zander (1992) as "knowledge which can be transmitted without loss of integrity" which includes facts, axiomatic propositions and symbols. Knowledge is also defined as "interpreted information in action for decisions" by Langefors (1966). These definitions indicate that knowledge is information, prepared and worked by individuals, to be used in practice. Both information and knowledge is necessary in order to develop new products in alliances, as well as in the individual firm. To integrate information and knowledge, a number of impersonal methods are suggested such as written documents, intranets, open computer servers or formal reports. But these impersonal methods should also be complemented with personal methods, such as joint work shops, personal meetings or joint post project evaluations (PPE).

It is interesting to investigate how the firms integrate the information and knowledge generated by the alliance's work to the firm. Which methods are used to what extent and how employees value the different methods.

This paper will begin with developing propositions from a theoretical framework. Then these propositions are tested in a case study of three firms, and conclude with discussion and some managerial implications.

THEORETICAL FRAMEWORK

In this section important terms will be defined and three propositions developed.

Defining Information and Knowledge

In order to fully understand the differences between information and knowledge, it is important to review basic definitions. There has been no shortage of researchers providing their own definitions of these terms which has created a difficult situation. Therefore my own definitions will not be presented, but rather a discussion of implications from definitions provided by some leading researchers. The definitions of information are often far less complex and more uniform than the definitions of knowledge. Information is usually defined as "Organized data" (Pedrycz, 2005); "Data endowed with relevance and purpose" (Drucker, 2001); "Interpreted data" (Langefors, 1966). These definitions are similar to many others that point to the fact that information includes human participation in the purposeful interpretation of raw data.

Defining knowledge, however, is a much more complex task. I will not discuss all the perspectives that have been offered, but highlight two main views have been put forth about how we learn and acquire knowledge: empiricism and rationalism (Nonaka & Takeuchi, 1995). The interplay between researchers from these two perspectives offers us the current and more accepted understanding about knowledge. That is, knowledge can only reside in the mind of an individual and is the result of human experience and reflection, based on a set of beliefs, which are at the same time individual and collective.

The same complexity is highlighted by some of the leading authors in the emerging field of knowledge management. For instance, Nonaka & Takeuchi's definition (Nonaka & Takeuchi, 1995) that "*Knowledge is true and justified belief*". In general, most

researchers point out the complexity of knowledge compared to information. The key difference between the two can be summarized by the role human beings play. In the case of knowledge, individuals play an important role as developers, carriers, spreaders and users. In the case of information, these same functions often reside “outside” the human being and without its direct influence.

This knowledge can be categorized as [1] the information or knowledge that is the results of the work in the alliance. These could either be intended results or accidental results. Results are either documented as implicit knowledge or stored in individuals as tacit knowledge (Nonaka, 1994). A second category of knowledge is [2] the know-how of the process of cooperation. This is knowledge and experiences gained on how effective cooperation is structured and conducted. A third category is [3] the general environmental information. This is market, technology and societal information that could be useful in future product development, but also includes a huge information overload to filter. Using the distinction between information and know-how (knowledge) (Kogut & Zander, 1992) and adding a third type of knowledge including the indirect environmental information, the framework covers an interesting set of dimensions.

Knowledge integration

In order to reach effective processes for product development, it is important to share knowledge between functions. In an alliance context that will mean sharing knowledge between organizational and geographically divided units. Therefore integration in this case means linking functionally separated departments or units, while preserving their individual orientation (Moenaert and Souder, 1990).

To achieve knowledge integration [1] personal and [2] impersonal interaction must take place (Frishammar and Hörte, 2005). Personal interaction could be participation in meetings or phone conversations, while impersonal interaction could be exchanging of e-mails or reports. A third method for integration is [3] direct collaboration. Collaboration could be informally working together or sharing the same vision. Their results show that collaboration is positively correlated with performance, while personal and impersonal interaction is insignificant.

A Joint framework for the study

By combining the two sets of dimensions, knowledge categorize and knowledge integration methods, a framework for the case study was developed (see figure 1). On the vertical axis, the knowledge categories can be described in terms of specificity. Moving from Thematic knowledge as technological knowledge of the product or user knowledge of the exact user group, up to a less specific knowledge (general knowledge) of, for example political situation or environmental trends. It could be suggested that the degree of success in knowledge integration depends on the degree of specificity of knowledge, as they are more or less suited to be expressed in implicit forms or tacit forms. The more implicit a knowledge is the closer to be defined as information. Information is in turn more suitable to be integrated by data transformation.

On the horizontal axis are placed the methods for achieving knowledge integration. These are positioned moving from impersonal interaction to collaboration, adding in each category more involvement. Earlier studies show a correlation between more involvement and innovation performance (Frishammar and Hörte,2005). This result is used to

formulate the first proposition (see below). As concluded before it could be suggested that more specific knowledge is possible to integrate with less involving methods as less specific knowledge needs more involvement in order to be integrated. This reasoning leads to proposition number 2 (see below).

Proposition 1: Knowledge integration will work more efficient the less involving methods are used.

Proposition 2: P1 is stronger the less specific knowledge is integrated.

A FRAMEWORK FOR STUDYING INTEGRATION OF KNOWLEDGE		**More Involving** ← **Less Involving**		
		Collaboration	**Personal interaction**	**Impersonal interaction**
More specific ↑ **Less specific**	**Thematic knowledge**			
	Process knowledge			
	General knowledge			

Figure 1. A suggested framework for studying knowledge integration based on the degree of involvement and the specificity of knowledge.

METHOD

A case study approach is used to investigate how different types of information and knowledge, generated in an alliance context, are integrated in the individual firm. For example, it is interesting to note which methods are used, which knowledge category is focused on, and also some indication of which methods are more successful for each type of knowledge.

The three firms in the study have been present in different research projects together with CPDR (Centre for Product Development Research, Halmstad) since 2001. This is important as it gives us an access to every department of the firms, employees as well as documents. We also have our own knowledge and opinion about how operations are run. In this specific study however the empirical base contains of 15 unstructured interviews with persons in the three firms. The firms are medium sized (between 200-1000 employees) and manufacturing. They all three also have an extensive R&D operation in-house, which is important for the study. Their industry could be defined as mechanical industry and construction material.

All the respondents are deeply involved in product development in an alliance context. Typically the respondents in a firm/case include R&D manager, HR manager, Production

manager and two project leaders/members of an ongoing product development project in an alliance context. The interviews where conducted during autumn 2005 and analyzed according to the above framework.

RESULTS

The interviews with management and project members in the three firms indicated that there is a rather high awareness about the terms and the concepts of the study as well as the phenomena behind the terms. These discussions around terminology and knowledge integration in general points to a good construct validity; that the terms of the framework are understood end interpreted the same way by all respondents and the interviewer. It also indicates that there is awareness about the importance of the area and an interest to improve knowledge and organization around the phenomena.

Effects from degree of involvement at knowledge integration

All three firms have today the major emphasis on impersonal methods for achieving knowledge integration. A pattern is that the project starts with a meeting between R&D managers in the alliance, discussing collective goal and mutual understanding. However, this meeting culture is not spread down to the project members, who rarely meet. During the project e-mail and exchange of reports are dominating methods for knowledge sharing, while the managers meet again two or three times at the end of the projects. Still it is interesting that project members are very much in favor of physical and informal meetings for sharing vision and ideas. This is also recognized by management, but still carried out more rarely.

Firm A has as a policy that all project members shall meet in the beginning of a project. They also used this policy earlier, but R&D manager explained that longer geographical distances have made it more difficult today. New suppliers in China have made travel costs extensive, while new communications technology has made it easier to motivate fewer physical meetings. However, in this case, the longer geographical distance also leads to a longer cultural distance, which would rather motivate more physical meetings to avoid misunderstandings. According to project members the fewer travels have lead to less knowledge integration both regarding process knowledge and general knowledge.

Firm B is the one that has most collaboration. The obvious explanation is that the partners in the alliance are geographically close. The managers meet the partners in the beginning of the project, during the project, and after the project. Management also claims that project members are to meet partners according to their own need. However, it seams that this is not spread in the project teams. Project members also confirm that there is a lot of discussion with the partner firms regarding project methodology and other types of process knowledge. There is a close understanding of joint values regarding for example the meaning of fulfilling goals and how to monitor and inform stakeholders of the projects. Physical meetings are in this alliance substituted by frequent phone meetings and open chat boards. This creates trust among the participants both on a personal and a professional level, which opens for informal sharing of ideas and values.

Firm C has been under economical pressure for a few years. Today, even though there is an awareness of the importance of collaboration, there is no money to do it fully. Pressure also has lead to a low organizational self esteem which makes it hard for project members

to communicate. Management shows in the quality handbook how communication shall be handled with impersonal methods, and do not motivate project members to share knowledge that is not described in the handbook. Project members are pleased with the structure that makes it easy to do right according to the instructions, but not with the knowledge exchange between the firm and their partners. Studying the project plans it appears that the problem is not lack of resources in the project, but the strong focus on information activities described in the handbook.

The three cases seem to support proposition 1, that knowledge integration will work more efficient the less involving methods are used. Firm B with the highest proportion of collaboration also has the highest degree of knowledge sharing and integration. Firm C with a strong philosophy supporting formal trails of information rather than knowledge sharing also has the lowest degree.

Integration of knowledge with different specificity

All three firms have a focus on integration of thematic knowledge. In product development projects this means that there are routines for how to share and integrate technological knowledge as about the product itself. That is how the product works, how it shall be produced, and deeper knowledge of technologies used in the product. Two of the firms have some integration of process knowledge as post project reviews (PPR). It became more difficult than expected to find general knowledge, but traces of integration of general knowledge was found in one firm as knowledge of technological trends and news about EU protection of patterns.

Firm A has a well developed system for integrating thematic knowledge. They do not refer to a quality standard, but have a strong culture and structure to support knowledge sharing of thematic knowledge. For example, a project management platform presents a checklist for how meetings, reports, and technical protocols shall be stored and shared. This system was developed and implemented when a few of the new alliance partners were on a long distance. The platform is also used for geographically closer partners, and has lead to a stronger emphasis on correct document sharing. The platform does as well prescribe post project reviews. These are normally carried out as exchanging of reports or e-mails, but have in a few cases lead to post project workshops. According to project members it has however also meant that fewer informal meetings with general knowledge sharing.

Firm B, with an alliance in a close distance and mainly focus on collaboration, seams to have a good integration of as well thematic as process knowledge. The process knowledge is in this case not only developed as PPR, but also in informal meetings during the project. Even though Firm B has a much less formalized monitoring system for projects, they seem to have a greater mutual understanding and shared vision than the other firms. Equally as in Firm B it was hard to find distinct examples of integration of general knowledge, even if both managers and project members state that they share a lot of this type of knowledge.

Firm C has a very strong focus on integration of thematic knowledge. Following the findings in Firm A. There are routines for gathering and sharing technological specifications and reports. Two years ago the Firm C had no integration of process

knowledge, but during the study they have increased their interest in post project reviews and learnt to carry out PPR workshops through knowledge spill over from Firm A. A first workshop will be carried out in the fall of 2007.

The three cases seem to support proposition 2, even if the material regarding general knowledge is scarcer than regarding thematic and process knowledge. Firm B with the highest degree of involvement has also the highest degree of integrating less specific knowledge.

DISCUSSION

The result, that high involvement increases knowledge integration efficiency, is important. Similar results using different frameworks have been presented before. For example Newell et al (2004) investigated collaboration and concluded that "strong social capital" is important for knowledge integration. Social capital could be gained by closer collaboration and is a concept close to trust.

Akgün et al (2005) investigated the effects of using a transactive memory system (TMS) in a distributed project development project. TMS is an example of how software can be used for both personal and impersonal interaction. In their quantitative study they concluded that this type of software supported knowledge integration. Software is normally connected with lower degrees of involvement and information processing, but in order to get to a higher level of involvement in distributed projects, especially long distance, TMS software could be a tool to communicate knowledge.

With a focus on thematic knowledge, Vachon and Klassen (2006) concluded that collaboration increased knowledge integration in a supply chain. The thematic knowledge in the study is practices on a green supply chain. The study shows indications that the integration of the thematic knowledge on environmental technology as well as the process knowledge on effectiveness in a supply chain is supported by collaboration.

Knowledge generated in a product development project has two different values. First in generated hopefully a product that can be commercialized on a market and generate profit. Second it adds to the firm's collective knowledge capital to be used in future development projects. In order to win maximum effect from investments made in distributed product development, the firm needs to integrate knowledge generated. Knowledge that is not integrated in the firm's collective knowledge capital is not made useful in future product development projects. The decision to invest in knowledge integration is a strategic decision. To do like Firm A and not invest in structures for integrating knowledge means that the firm in the future depend on the alliance in order to access the same knowledge. It also means that the firm is not able to communicate around the knowledge or to develop further knowledge in the same field. Firm C get the same disadvantages. However, Firm C chose not to invest in cultures for integrating knowledge.

Discrepancy between perceived and real situation

An interesting result that was not a purpose of the study is that all three firms have a high awareness of, even a desire, to have a higher degree of knowledge integration. The ambition to collaborate and share knowledge with methods that are more involving is also high. Another interesting observation is that project members are even more aware and

interested in increasing collaboration than management. Still there is a threshold to pass for the firm in order to increase the more involving methods. Firm A with a long distance alliance should probably be the firm to gain most from more involving methods. The start of using such would be an investment in the knowledge sharing with its alliance partners even if initially appearing a big cost. Maybe a research project as this study can trigger such actions as it has done in Firm C starting up post project reviews as a result of the study.

Managerial implications

This article provides some guidance for project members and managers involved in distributed product development projects. It is important to note that managing knowledge in alliances is an important problem and that the main challenge is primarily related to degree of involvement. Firms in alliances need to better understand that not only the results of the project, but also the process knowledge of handling the co-operation between firms in an alliance. This integration can be nurtured both with culture (motivation or informality) as structures (checklists or organization charts).

The terminology for categorizing type of knowledge and integration methods may be useful to working managers by both describing a set of idealized types and examples, as well as correlation between the two sets of categories. Increased awareness of the terminology along with the correlations may assist managers to appropriately initiate actions to nurture structures and culture for knowledge integration.

More generally, managers have the ability to enhance knowledge integration effectiveness through deploying their human capital, turning "knowledge into action" (Pfeffer and Sutton, 1999). Managers should allocate their resources carefully because it can show that an investment in collaboration can increase the involvement considerably. Increased collaboration we can assume leads to better knowledge integration, which in turn could lead to better use of the knowledge created in the project.

CONCLUSION

The objective of this study was to investigate how different types of knowledge, generated in product development in an alliance context, are integrated to the individual firm. In order to reach the objectives a framework of three categories of knowledge and three levels of involvement in the alliance was presented.

Two propositions were made: P1) Knowledge integration will work more efficient the more involving methods are used, and P2) P1 is stronger the less specific knowledge is integrated. Both propositions were supported in a longitudinal case study of three medium sized manufacturing firms.

REFERENCES

Akgün, Ali; Byrne, John; Keskin, Halit; Lynn, Gary and Imamoglu, Salih. (2005). Knowledge networks in new product development projects: A transactive memory perspective. Information & Management, 42 (8) : 1105-1120.

Brown, Jim. (2005). Aberdeen Group: Global Product Design Benchmark Report. Available from: http://www.aberdeen.com/summary/report/benchmark/RA_GlobalProduct_JmB_2460.asp , [accessed: 2007-03-30].

Drucker, Peter. (2001). Management Challenges for the 21st Century. New York: Harper Business Press.

European Commission-Eurostat. (2004). Innovation in Europe. Results for the EU, Iceland and Norway. Data 1998-2001. Luxembourg, European Commission.

Frishammar, Johan and Hörte, Sven-Åke. (2005) Managing external information in manufacturing firms. Journal of Product Innovation Management 22 (3), 251-266.
Grant, R.M. (1997) The knowledge-based view of the firm: Implications for management practice, Long Range Planning, 30, 450-454.

Hamel, G. and Prahalad, C. (1990) The core competence of the corporation, Harvard Business Review, 68(3) : 79-91.

Jolly, Dominique. (2004). Bartering technology for local resources in exogamic Sino-foreign joint ventures. R&D Management 34 (4), 389–406.

Kahn, Kenneth. (1996) Interdepartmental integration: A definition with implications for product development performance. Journal of Product Innovation Management 13 (2), 137-151.

Kahn, Kenneth; Castellion, George and Griffin, Abbie. (Eds.) (2005). The PDMA Handbook of New Product Development.

Kogut and Zander. (1992). Knowledge of the firm, combinative capabilities, and the replication of technology. Organization Science 3 (3) : 383-397.

Langefors, Bo. (1966). Theoretical analysis of information systems. Lund: Studentlitteratur.

McGrath, M.; McMillan I. and Venkataraman, S. (1995). Defining and Developing Competence: A Strategic Process Paradigm, Strategic Management Journal, 16 (4) : 251-275.

Moenaert, R. and Souder, W. (1990). An information transfer model for integrating marketing and R&D personnel in new product development. Journal of Product Innovation Management 7 (2), 91-107.

Newell, Sue; Tansley, Carole and Huang, Jimmy. (2004). Social Capital and Knowledge Integration in an ERP Project Team: The Importance of Bridging and Bonding. British Journal of Management 15 (1), 43–57.

Nonaka, Ikujiro. (1994). A Dynamic Theory of Organizational Knowledge Creation. Organization Science 5 (1), 14-37.

Nonaka, Ikujiro and Takeuchi, Hirotaka. (1995). The Knowledge Creating Company. New York: Oxford University Press.

Pedrycz, Witold. (2005). Knowledge-Based Clustering. New Jersey: John Wileys & son.

Pfeffer, J. and Sutton, R. (1999). Knowing 'What' to Do is Not Enough: Turning Knowledge into Action. California Management Review 42 : 83-108.

Polanyi, Michel. (1983 [orig. 1966]). The Tacit Dimension. MA, Magnolia, Peter Smith.

Teece, David; Pisano, G. and Shuen, A. (1997) Dynamic Capabilities and Strategic Management, Strategic Management Journal, 18 (7) : 509-533.

Vachon, Stephan and Klassen, Robert. (2006). Extending green practices across the supply chain: The impact of upstream and downstream integration. International Journal of Operations & Production Management 26 (7) : 795 – 821.