

Knowledge Acquisition Models of SMEs' New Product Development Processes and the Role of Patent Information

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Abstract

Successful new product development (NPD) activities need high amounts of new knowledge from a variety of different sources. When the NPD activities are seen as a process of knowledge accumulation, two knowledge processes are identified: knowledge acquisition and knowledge utilization. This study focuses on the process of knowledge acquisition from external knowledge sources in the NPD of SMEs. Based on a comparative case study research design, three knowledge acquisition models are identified, and the used knowledge sources and the role of patent information in these models are discussed. The findings show that there is a relationship between the NPD processes and the ways the knowledge is acquired from the external environment, but on the other hand, the knowledge acquisition models identified do not correspond to the previous studies about knowledge acquisition in terms of the environmental scanning framework. Thus further studies are needed to understand the relationship between the type of knowledge acquired and the scanning-interpretation modes used by organizations.

Keywords

knowledge acquisition, new product development (NPD), patent information, knowledge processes

Acknowledgements

This study is funded by Tykes (the Working Life Development Programme of the Finnish Ministry of Labor, nr.T41187) as a part of *Idealuotsi*, a larger research project conducted by the National Board of Patents and Registration of Finland.

Introduction

New information and knowledge are expected to be critical to success and competitiveness of companies. This conviction has been elaborated towards a knowledge-based view of the firm, according to which the key to competitiveness is the firm-specific knowledge assets of the organization (Boisot 1999; Teece et al. 1997). The knowledge-based view of the firm indicates that creating, organizing, and using knowledge assets are in fact the essence of what firms do (Kogut & Zander 1996; Spender 1996).

Knowledge assets are especially important in knowledge-intensive activities such as in new product development (NPD). In recent years, high competition in many industries has forced companies to improve their NPD process in order to develop new, high quality products in an

increasingly rapid pace. At the same time, the increase in the amount of knowledge available for organizations seems to increase complexity of NPD activities. Therefore it is important to understand knowledge processes such as knowledge acquisition, knowledge transfer, knowledge creation and knowledge utilization that are included in the NPD process.

For all companies new information and knowledge is a critical resource, but this is especially true for small and medium sized enterprises (SMEs), due to their scarce resources and the need to focus the existing resources on their daily activities. Still, the research in the area of knowledge management has mainly concentrated on large companies. Therefore, this study focuses on knowledge acquisition in a knowledge intensive activity, NPD, in SMEs.

The role of knowledge in the NPD process

Knowledge-intensive activities are characterized by the requirement to gather information, and convert information to knowledge (Schilling & Hill 1998). Successful innovation and NPD activities are expected to need large amounts of new knowledge. In research about innovation and NPD, innovation is expected to originate from new knowledge creation (Nonaka & Takeuchi 1995), from new combinations of existing knowledge (Cohen & Levinthal 1990; Kogut & Zander 1992), and from the application and utilization of knowledge (Shani et al. 2003).

To grasp the role knowledge plays in the NPD process, we need to model the NPD process. Based on the knowledge-based view of the firm, several models of the NPD that emphasize the external linkages of the organization coupled with the internal activities (Hagedoorn 1990; Nonaka & Takeuchi 1995; Trott 2002) are presented. Several studies also suggest that external linkages actually facilitate additional knowledge transfer into the organization, thus enhancing the NPD process (Cusumano & Takeishi 1991; Liker et al. 1995). Therefore, the NPD should be viewed as a knowledge accumulation process that requires inputs from a variety of sources. These models are called network models of NPD. In the network model, the NPD is a process of accumulation of knowledge from a variety of different inputs, both internal and external to the organization. The knowledge builds up gradually over time as the NPD project progresses. (Trott 2002, 218-219)

The process of knowledge accumulation is usually divided into two knowledge processes: knowledge acquisition and knowledge utilization (Soo et al. 2002). In the NPD context, the **knowledge acquisition** is twofold. First, new external knowledge has to be searched or discovered in the external environment and then transferred into the NPD process. Second, this new knowledge will trigger new ideas and thus contribute to the internal knowledge creation. **Knowledge utilization** integrates this new knowledge with the existing knowledge base and into the NPD process, thus turning the knowledge into new products. In this study we focus on the external knowledge acquisition process, which will be discussed in more detail in the following.

Knowledge acquisition in NPD

The key element for successful NPD is actually the *newness* of the knowledge or the *new* way of combining existing knowledge, integrating this knowledge into the NPD process and thus embodying it in the developed products. However, this new knowledge does not have to be newly created, only new to the organization (Davenport & Prusak 1998). The idea that

companies need external sources of knowledge is not new (Jewkes et al. 1958; ref. Almeida et al. 2003). However, existing knowledge management research literature following the seminal work of Nonaka (1991, 1994), emphasizes mainly the role of internal knowledge creation activities (Nonaka & Takeuchi 1995; Carbonara & Schiuma 2004). Even if knowledge seeking activities are found to correlate positively with general company performance (Daft et al. 1988) and NPD performance, existing research has not so far extensively studied the role of the new knowledge acquired from the environment.

On the other hand, the studies that have actually studied acquisition of new knowledge have mainly concentrated on knowledge acquisition through collaborative relationships, e.g. alliances, partnerships, and joint ventures (Järvenpää & Mäki 2005). Several studies have examined how knowledge can be transferred between organizations and how different collaborative relationships create learning opportunities that can be pursued (Dyer & Singh 1998; Tsai 2001). Without denying the importance of interorganizational knowledge spillovers, there seems to be a lack of a holistic view that would take into consideration *all* the external knowledge sources, i.e. human, textual, and electronic sources (Choo 2000, 138-141).

External knowledge can come from human, textual or electronic sources. Human sources include e.g. customers, suppliers and partners, and are mainly related to different interorganizational relationships. Textual sources include published, written or broadcasted sources such as newspapers, radio or television. Finally, electronic sources supply information through computers and telecommunication networks such as external online databases and other resources on the Internet. (Choo 2000, 138-141). Pursuing a holistic view of knowledge acquisition, our **first aim is to model the knowledge acquisition of NPD in SMEs.**

The ways organizations address different knowledge sources and knowledge types in NPD have not sufficiently been addressed in existing research. On a more general level, research has examined environmental scanning, i.e. acquisition and use of knowledge about changes in organization's external environment (Auster & Choo 1993; Choo 2000, 71-74). Building on the seminal work of Aguilar (1967) and Weick (1979), four modes of scanning-interpretation of the external environment have been differentiated in the environmental scanning framework: undirected viewing, conditioned viewing, enacting, and discovery (Daft & Weick 1984; Choo 2000, 82-85, Figure 1).

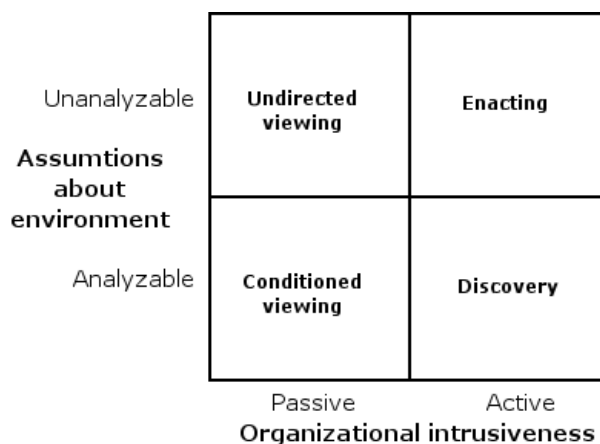


Figure 1. The environmental scanning framework presenting the four scanning-interpretation modes (modified from Choo 2000, 83).

This differentiation is based on the two dimensions of environmental analyzability and organization intrusiveness. Environmental analyzability refers to the organizations beliefs about how analyzable the environment is, i.e. how determinable and measurable different events and processes are, and if a 'correct' interpretation is possible through systematic information gathering and analysis. Organizational intrusiveness refers to the activeness of the organization to intrude its environment, i.e. if resources are allocated for information search and for testing or manipulating the environment. (Choo 2000, 82-83)

Undirected viewing takes place when the organization perceives the environment as unanalyzable and so does not intrude into the environment to understand it. Much of the knowledge is thus informal or non-routine, and knowledge acquisition is very opportunistic, relying more on irregular contacts and casual knowledge from personal human sources. On the other hand, *conditioned viewing* takes place when the organization perceives the environment to be analyzable but is passive about gathering knowledge and influencing the environment. A significant amount of knowledge comes from records and information systems, as the knowledge acquisition is passive, based on detection more than discovering. (Choo 2000, 83-84)

Enacting takes place when the organization perceives the environment to be unanalyzable but then actively intrudes into the environment in order to influence events and outcomes. The knowledge acquired is informal, but it is based on active search of feedback to learn and test the environment. Finally, *discovery* takes place when the organization perceives the environment to be analyzable and it actively intrudes into the environment to collect knowledge in order to find the correct interpretation. The knowledge is often hard, formal, quantitative data, typically from surveys, market research, and forecasts. (Choo 2000, 84)

The knowledge sources can be divided into formal knowledge sources, where knowledge is in an explicit form publicly available and into informal knowledge sources, where knowledge is embedded in humans or other sources not publicly available. This distinction is important, as the type of knowledge affects knowledge acquisition and utilization (Lane & Lubatkin 1998). However, in this study, we did not separate tacit and explicit knowledge as types of knowledge to be acquired, but focused on sources and acquisition of knowledge as such.

On the other hand, the types of knowledge can be divided into technological knowledge and business knowledge. Technological knowledge includes knowledge about the core technology and methods of the organization. Business knowledge deals with knowledge on competitors' products, markets, user needs and other relevant knowledge in turning the known technology into an actual successful product. Different types of knowledge can be assumed to be acquired through different kind of knowledge sources. Accordingly, our **second aim is to identify the knowledge sources used in NPD of SMEs**. Special attention will be paid to patents as a knowledge source, which will be discussed in the following.

Patent information as a source of knowledge for the NPD

Patent information means the information contained in public patent documents published by the various national patent offices around the world. The patent documents contain very detailed, applied technical information. According to the Finnish National Board of Patents and Registrations, today almost 40 million patent documents have been published, describing approximately 15 million different inventions internationally. The annual number of new

patent documents is currently approximately 1.5 millions. Patent information becomes public after 18 months of the filing of the patent, and it can be accessed through all the patent offices. The information is also increasingly available on the Internet (e.g. the Finnish site at <http://fi.espacenet.com>).

Patent documents are thus a huge database that can be used as a knowledge source. As the patent document publication is a requisite for obtaining a patent, almost all the technical information relevant from a commercial point of view is available through patent documents. The European Patent Offices (EPO) estimates that 80% of the technical information contained in a patent document is never published anywhere else (Poynder 1998). Even if the same knowledge is published elsewhere, new patent documents usually contain knowledge that has not yet been published in other knowledge sources and patent information is thus the first source of knowledge (Choo 2000, 150-156).

Patent documents contain large amounts of relevant new knowledge for companies. This knowledge is especially important in NPD as it may be easily applied into various NPD activities. EPO suggests that the use of patent information can e.g. reduce the risk of “reinventing the wheel” and help companies to monitor their competitors’ research activities. The patent document has also been calculated to generate more savings when actually used in NPD than any other formal knowledge source: approximately 13 400 euros worth of saving per one patent document (Nelke 2000).

However, patent information seems to be one of the least appreciated sources of knowledge (Poynder 1998). It is estimated that even 30-50% of NPD efforts are overlapping, i.e., companies are trying to solve problems that already have been disclosed among patent documents (Koch 1991; Trevor 1994). On the European level, EPO estimates the cost of this duplicate research at 17 000 million euros a year (Poynder 1998). Patent information is not extensively used, especially in SMEs. However, large companies use patent information more extensively, especially in certain sectors such as the chemical and pharmaceutical industries. SMEs and other industries (such as engineering) are at best intermittent users: patent activities are often limited to their own patent applications or identifying the characteristics of one specific patent. (Ashton & Sem 1988) As SMEs do not always utilize patent information in their NPD processes, our **third aim is to identify the role and importance of patent information in NPD of SMEs.**

Goals of the study and research questions

The objective of this study is to explore knowledge acquisition processes from external knowledge sources in the NPD processes of SMEs. The research questions are as follows.

1. What kind of knowledge acquisition models can be identified in NPD of SMEs?
2. What knowledge sources are used in the NPD of SMEs using different kinds of knowledge acquisition models?
3. What is the role of patent information in the NPD of SMEs using different kinds of knowledge acquisition models?

Materials and methods

This study is a comparative case study, with a total of 14 case companies in manufacturing industry. The case study approach with mainly qualitative data was used because the topic, knowledge acquisition models in NPD is not extensively studied, and the aim was to identify the knowledge acquisition models used (Yin 1994).

All the case companies fulfill the requirements for SMEs according to the European Union definition (European Union 2003). The case companies were chosen to represent a variety of branches of manufacturing industries as well as a variety of size. Six of the case companies were small, they employed from 7 to 26 employees, and their turnover varied from 0,3 to 7,8 million euros. These companies were from machine and metal, electrical and electronics, and chemical industry (SIC, Statistics Finland 2002). Eight of the companies were medium-sized, employed from 58 to 230 employees, and had a turnover between 7,8 and 45 million euros. The medium-sized companies were in machine and metal, and electrical and electronics industry (SIC, Statistics Finland 2002). All the case companies were from Southern and Western Finland.

In each case company both qualitative and quantitative data were collected using interviews and questionnaire surveys. Internal company documents were used if necessary. Afterwards a feedback workshop was organized in each case company to present, discuss and validate the results. In all the case companies, the head of the NPD unit (CTO or R&D director) was interviewed. In some companies, the head of the NPD unit was interviewed together with other key personnel participating in the new product development. The total number of interviews was 15 with a total of 21 interviewees (see Appendix 1). The interviews were thematic interviews focused on the nature and organization of the NPD inside the company, the NPD process i.e. the phases in the NPD, the tasks and activities in each phase, the design and work methods and the knowledge sources used in NPD, and internal knowledge sharing practices (Hirsjärvi & Hurme 1980). Patents were treated as one knowledge source.

The questionnaire survey was carried out after the interviews using either a paper or a digital questionnaire form. The questionnaires were distributed to all the employees involved in the case companies' NPD as defined by the heads of the NPD unit in the interviews. Besides the employees working inside the NPD unit also other employees working e.g. in technical design, production, sales and marketing or general management were asked to fill in the questionnaire if they participated actively in the actual NPD activities. The number of respondents varied between 2 and 15 per case, and the total number of respondents was 69 out of 110 employees contacted (see Appendix 1). The response rate was above 25% in each case company, and the average response rate per case company was 72%. The questionnaire dealt with 1) both internal and external knowledge resources used in the NPD, 2) the type of knowledge acquired through each information resource, i.e. to what aspect or activity of NPD the knowledge was related to, and 3) the knowledge sharing inside the company and the NPD, i.e. with whom inside the company the respondents shared knowledge with.

Each case data was analyzed in three phases. In the first phase a qualitative analysis method was used to understand the NPD activities and practices in each case. The interviews were coded using deductive analysis on the aspects of nature of NPD (customers, markets and competition, products, technology involved), general NPD strategy, organization of NPD

activities (organizational design, distribution of tasks, outsourcing), nature of NPD practices (number of NPD projects, customer and partner involvement etc.), NPD process, i.e. the identified phases in the NPD, and detailed activities taking place in each phase, general knowledge management practices inside NPD, sources of knowledge used in the NPD (both internal and external), use of patent documents as knowledge sources, and knowledge sharing practices used inside NPD. Based on this content analysis of the interviews, a model of the actual NPD process was formed according to the described phases and activities. Here the process phases were named according to the description of the phase activities (i.e. idea generation, concept design, system design, electrical engineering, prototype testing etc.). In two cases, also internal company documents describing the formal NPD process were used to help determine all the activities taking place in each phase. Also the key decision point of when the product is decided upon (product decision) was recorded.

In the second phase, a model of the knowledge flow in the NPD process in each case company was formed based on the questionnaire survey. For this purpose, a social network analysis was conducted determining the connections between the NPD personnel and the used knowledge sources according to the type of knowledge acquired (business or technological knowledge). The weight of each connection, i.e. the amount of use for each knowledge source per person was determined using the number of times the knowledge source was indicated in the questionnaire responses and its attributed importance. Also the central people in the social network consisting of NPD people were determined for both external and internal knowledge sharing.

In the third phase the amount of use for of each knowledge source per case company was determined by combining all the connections of the NPD personnel with the knowledge sources. This amount of use was used to calculate how much each case company used formal and informal knowledge sources by adding up the use of all the formal and informal knowledge sources. The amount of use of formal sources was then compared to the amount of use of informal knowledge sources in order to determine the ratio of formality. (So, if the ratio is between 0 and 1, more informal knowledge sources are used, and if above 1, more formal knowledge sources are used.) Finally, based on both the findings of content analysis and the social network analysis, the level of organizational intrusiveness (active or passive) was determined.

After all the cases were analyzed one by one, a cross-case analysis was conducted to determine if general patterns about knowledge acquisition would emerge. First the phases and activities of the identified NPD processes were compared to distinguish general types of activities, naming similar activities between the cases in the same way using established definitions of NPD process phases (Ulrich & Eppinger 2004). Then the ratio of formality of knowledge sources (formal or informal) for both business and technological knowledge, the organizational intrusiveness (active or passive), and the NPD process models were compared. Based on this comparison, three groups of companies were found.

Results

The comparison of the case companies revealed three separate groups (Table 1). The environmental scanning framework shows that the groups of interactors and integrators

correspond quite well with the scanning-interpretation modes of enacting and conditioned viewing (Figure 2). On other hand, the group of observers does not fit with any mode presented in the framework, but it seems to combine two scanning-interpretation modes: discovery for technological knowledge, and undirected viewing for business knowledge.

Table 1. The cross-case analysis with the ratio of formality for both technological knowledge and business knowledge, and the organizational intrusiveness.

	Technological knowledge			Business knowledge			Groups	
	Ratio of formality		Org. intrusiveness	Ratio of formality		Org. intrusiveness	Comparison	
Company 1	formal	2.03	active	informal	0.38	active	both	3
Company 2	informal	0.43	active	informal	0.25	active	informal	1
Company 3	formal	2.15	passive	informal	0.85	active	both	3
Company 4	formal	1.79	active	informal	0.20	active	both	3
Company 5	informal	0.90	active	informal	0.56	active	informal	1
Company 6	formal	1.02	active	informal	0.80	active	both	3
Company 7	formal	1.40	passive	formal	1.19	passive	formal	2
Company 8	informal	0.25	passive	informal	0.16	active	informal	1
Company 9	informal	0.92	active	informal	0.21	active	both	3
Company 10	informal	0.37	active	informal	0.64	active	informal	1
Company 11	formal	1.09	passive	formal	1.12	passive	formal	2
Company 12	formal	1.44	passive	formal	1.04	passive	formal	2
Company 13	formal	1.10	passive	informal	0.91	passive	formal	2
Company 14	formal	1.90	passive	formal	1.02	passive	formal	2

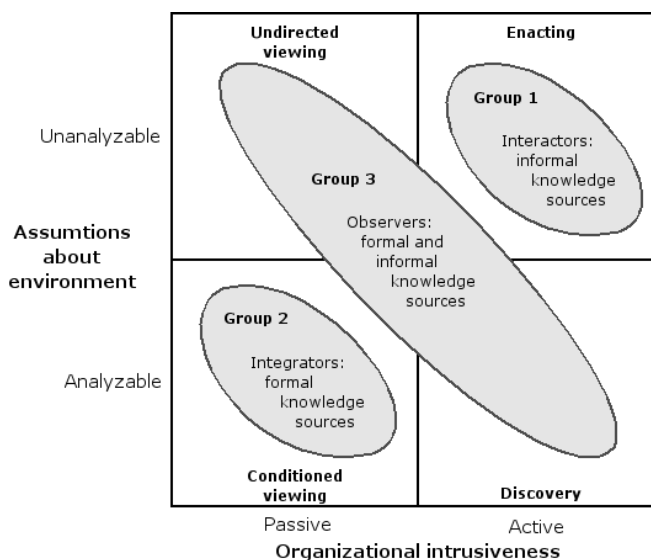


Figure 2. The three groups in the environmental scanning framework (see Choo 2000, 83).

The first group, the **interactors**, included four case companies who used mainly informal knowledge sources for both business and technological knowledge, and who were mainly active in their knowledge acquisition. The organizational intrusiveness was active for both business and technological knowledge with one exception with company 8. The second

group, the **integrators**, consisted of five companies. They used mainly formal knowledge sources for both business and technological knowledge with one exception with company 13. They were mainly passive in their organizational intrusiveness for both business and technological knowledge. However, the third group, the **observers**, broke the informal-formal distinction found in the other two groups. Among observers, the organizational intrusiveness was always active for both business and technological knowledge (with one exception). On the other hand, the knowledge sources that these companies had were of divided nature, i.e. both informal and formal. However, the two types of knowledge, business and technological, were acquired through different knowledge sources: business knowledge from mainly informal sources and technological knowledge from mainly formal sources (with the exception of one company).

The cross-case analysis revealed also that the found differences in the NPD processes were explained these three groups. This may indicate that the knowledge acquisition behavior and the NPD process models are interrelated. We will now describe these three groups, i.e. the interactors, the integrators and the observers, in more detail and present the related knowledge acquisition models. Afterwards we will focus on the role of patent information found in these models.

Three models of knowledge acquisition: the interactors, the integrators, and the observers

The interactors are companies that acquire knowledge actively through mainly informal sources. These companies were active or even proactive towards the markets in which they were embedded in, and tried to influence the evolution of these markets e.g. through partnership formation, forming informal or formal industry collaboration networks, participating in local regional development initiatives, keeping in contact and discussing with research institutes, or participating in standardizing organizations. The knowledge sources were often used in a very interactive way in the NPD process, so opinions and feedback were searched for even quite specific problems or ideas that arouse inside the NPD. Most of the interactors were small companies (four out of five companies in the group).

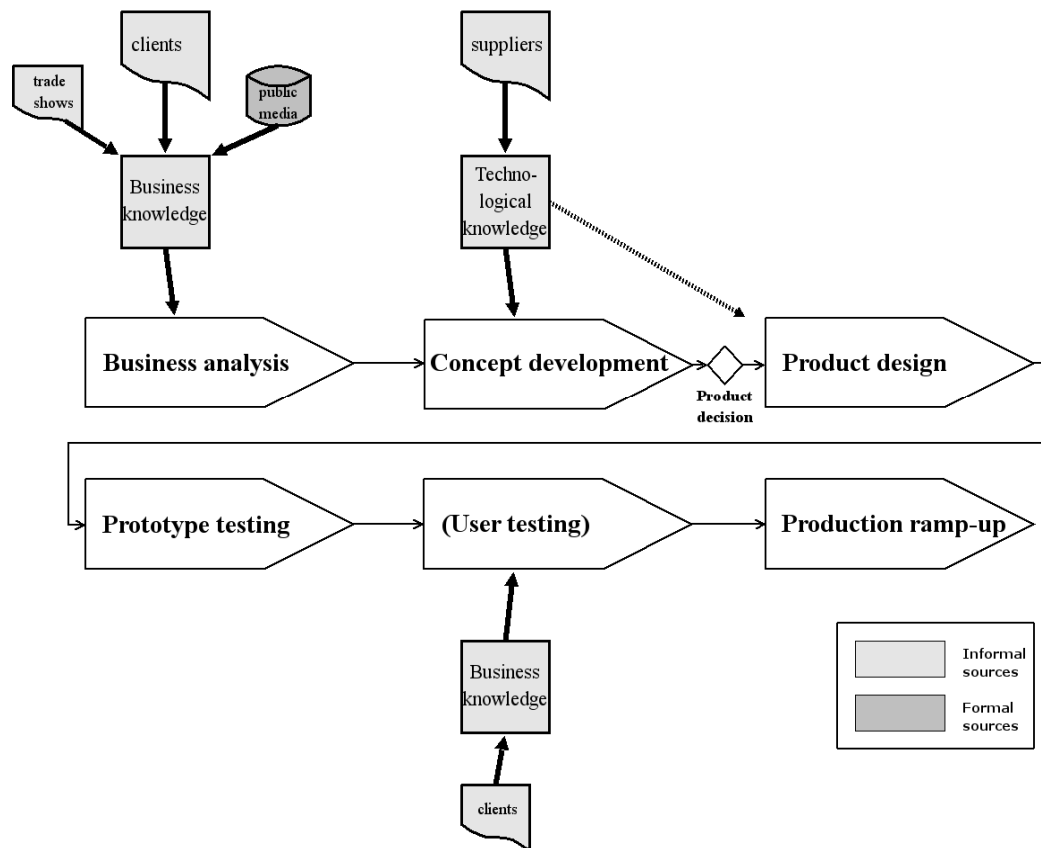


Figure 3. The knowledge acquisition model of the interactors.

The NPD process of the interactors starts of with the business analysis phase, where business knowledge is acquired. The main knowledge source is clients, but also trade shows and public media are used often. After the business analysis phase is the concept development phase, where technological knowledge is acquired mainly from suppliers. (Figure 3)

The integrators are companies that acquire knowledge quite passively through mainly formal sources. These companies expect not to be able to influence the evolution of the markets in which they are embedded in, so they concentrate on observing and understanding their environment in order to find the best ways to adapt to the environment. These companies often have certain permanent ways of doing things, i.e. certain knowledge sources are always used even if people do not know anymore if they are the best knowledge sources available. These knowledge sources used are mainly formal, and the informal knowledge sources are not usually considered relevant or reliable. All the five companies in this category were medium-sized companies in industries with relatively established technologies (all in the machine and metal industry).

The NPD process of the integrators starts of with the concept development phase, where technological knowledge is acquired. The main knowledge source is professional literature, but also scientific literature, public media and suppliers are used often. After the concept development phase is the business analysis phase, where business knowledge is acquired mainly through a variety of knowledge sources: public media, professional literature, clients

and trade shows. After this the NPD process follows the typical order of product design, prototype testing, a possible phase of user testing and finally the production ramp-up. (Figure 4)

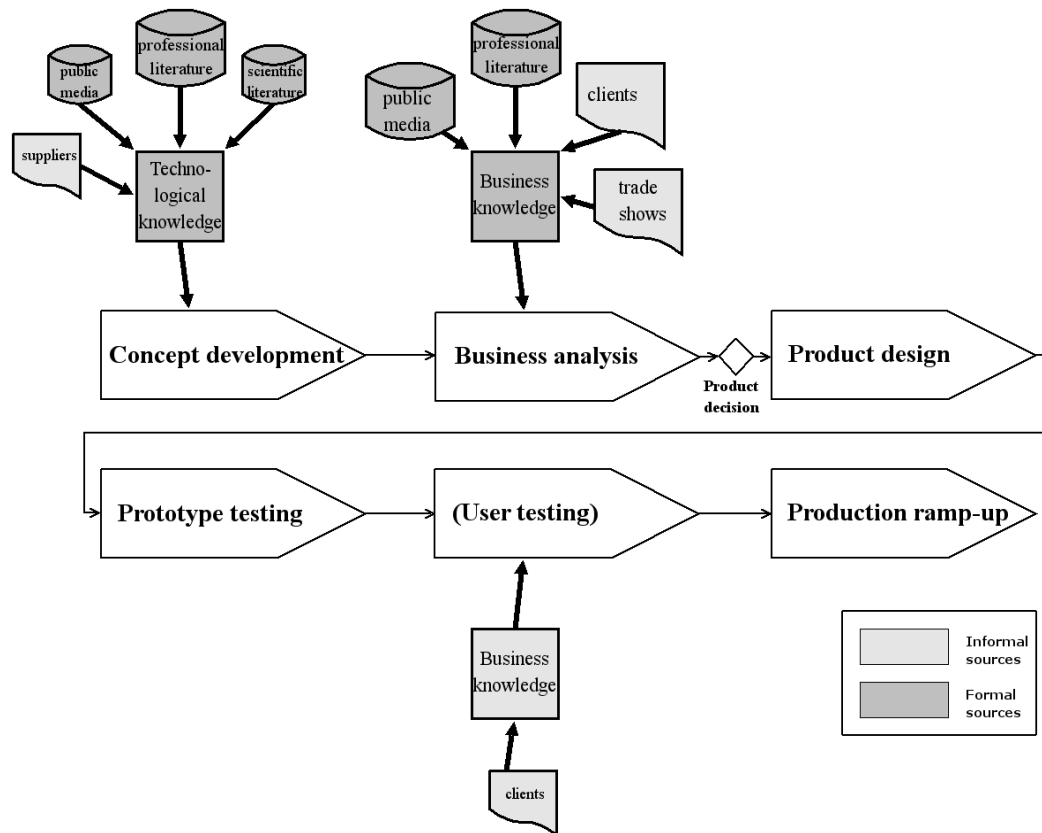


Figure 4. The knowledge acquisition model of the integrators.

The observers are companies that acquire knowledge from different knowledge sources depending on the knowledge type (business or technological knowledge). These companies acquire business knowledge mainly through informal sources, but on the other hand rely mainly on formal sources for technological knowledge. They do not really try to influence the markets in which they are embedded in, but they often try to influence on their environments by developing new markets through developing new technologies, methods or new kinds of products based on relatively new technology. Many of the companies had close relationships with different research institutes or were actively involved with the academic research community. The observers usually have also a very close relationship with their clients, and the NPD is often based on new customer demands, as for many companies new products were developed by customer-specific projects that were afterwards revised into standard products. The observers were mainly small companies (four out of five) and mostly in the electrical and electronics industry (four out of five).

The NPD process of the observers resembles the NPD of the interactors when the phases and the order of the NPD process are compared. Among the observers the product decision is taken on a very early stage, already after the first phase of business analysis, where business knowledge is acquired. The main knowledge source for the business knowledge is clients, but also trade shows are used often. After the business analysis phase and the product decision is the concept development phase, where technological knowledge is acquired mainly through

professional and scientific literature. After this phase the NPD process follows the typical order of product design, prototype testing, a possible phase of user testing and finally the production ramp-up. (Figure 5)

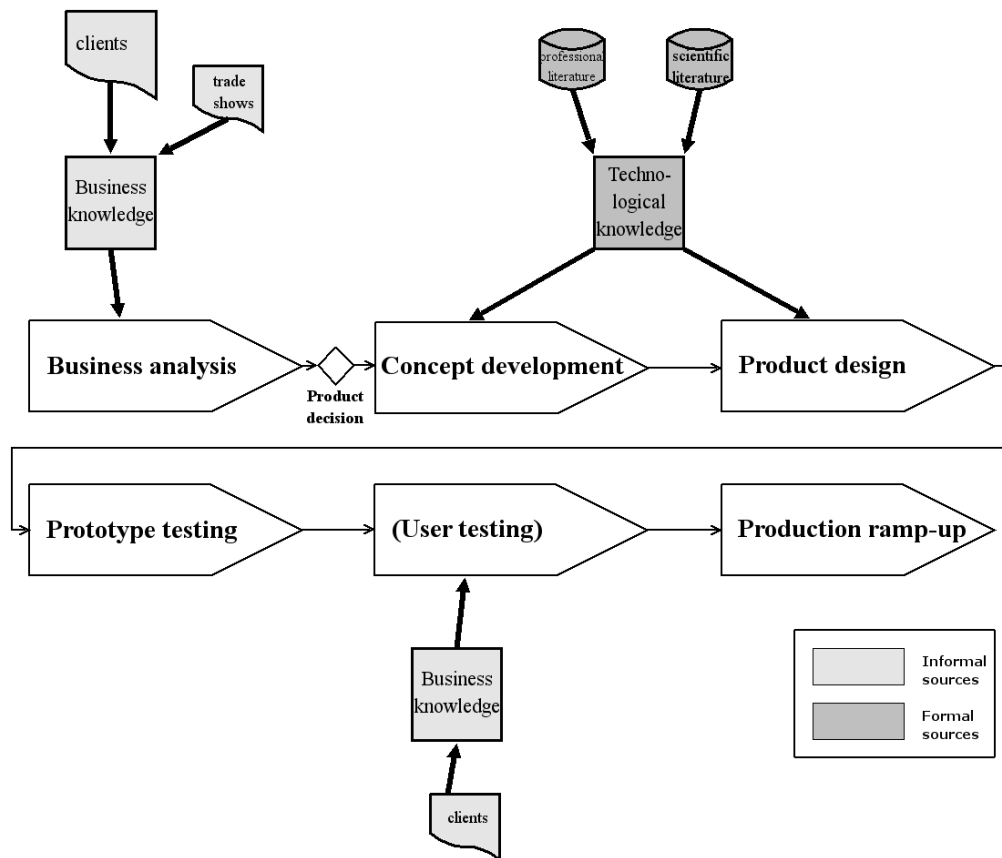


Figure 5. The knowledge acquisition model of the observers.

The role of patent information in the knowledge acquisition models

All three knowledge acquisition models indicate that the role of patent information is not very important for any of the three groups. According to the interviews, altogether seven companies used patents as a knowledge source in their NPD process, but the search for this kind of knowledge does not seem to be systematic, and the patent documents acquired were not analyzed. The main role of patent information seems to concentrate on following in general what other companies are doing, but not on the discovery of different technical solutions, technological development analysis, or competitor analysis. These results confirm the findings of previous studies (e.g. Nelke 2000), that have found out that patent information is available and is somewhat used, but it is rarely appreciated by the companies.

The main problems in the use of patent information reported by the companies was the lack of information about the methods and tools they could use to analyze patent information, the lack of internal resources that could be used for this analysis, and the lack of offering of adequate patent services. Six companies used the services of different patent agencies, but their services were found to be limited and/or of bad quality.

Discussion

The findings show that the NPD processes inside each group were quite similar. This indicates that the NPD process and the knowledge acquisition from external knowledge sources are related to each other. Depending on the NPD process, external knowledge sources seemed to be selected and used to fit with the knowledge need. We can thus conclude that there seems to be some kind of contingency between the way the organizations perceive their environment and their activity towards their environment, as stated by the environmental scanning framework, and how they actually acquire knowledge from their environment.

However, the three knowledge acquisition models in NPD do not directly correspond to the four modes of scanning-interpretation. This study does not provide explanation for this difference. However, the environmental scanning framework was originally developed for managerial purposes. Therefore it may not take into account the complex nature of NPD activities, where both purely technological aspects and business aspects of transforming the technology into a viable product have to be taken into account. The type of knowledge could therefore be a driver for the mode of scanning-interpretation, and thus the four scanning-interpretation modes would not be specific to the organization, but specific to the type of knowledge acquired in a certain group of organizations. This way the different scanning-interpretation modes could be used related to different types of knowledge.

On a more practical level, the three knowledge acquisition models can be used as a basis to determine what kind of knowledge sources certain companies can benefit from. For example patent documents are, in their basic format, highly formal, which makes their use especially difficult for companies depending more on informal knowledge sources.

The knowledge sources used in the three knowledge acquisition models were quite different for technological knowledge and business knowledge. The clients are of course an important source of business knowledge in all the three models, but this knowledge can be counterbalanced with other knowledge sources (the integrators), or only complemented with other informal knowledge sources (the interactors and the observers). The knowledge sources used for technological knowledge vary from professional literature to scientific literature and to suppliers, and present more variety than the knowledge sources for business knowledge. This might suggest that the variables of industry and newness of the technology play a more important role than this study is able to show.

The role of patent information was found not to be very important in knowledge acquisition models. Patent information is not a very easily approachable knowledge source, as the knowledge has to be somewhat 'reinterpreted' before it can be used in NPD (the knowledge is highly context-specific). This may inhibit many organizations to use patent information as the 'cost' of knowledge seems to be high.

In the future, the lack of knowledge about the ways how to use patent information and the lack of services related to processing and utilization of patent information should be addressed in order to enhance the use of patent documents as a knowledge source. This means the development of instructions and training services offered to SMEs, and the development of new kind of knowledge-intensive business services (KIBS) in the area. These new KIBS would be most beneficial for organizations that use more informal knowledge sources in NPD. For these organizations, the patent information should be refined and presented in a

format that suits them. In the future if the use of patent information increases in SMEs NPD, its role will hopefully become more important as its appreciation will also increase. In this case further research should be done in order to determine how this new knowledge source changes the knowledge acquisition models.

Limitations of the study and further research

As the number of cases used in the study was quite small, the results can not be generalized to SMEs in general. However, the findings may be applicable in similar SMEs as were studied in this study. The results are indicative when showing the relationship between the NPD process models and the way knowledge is acquired from external sources. Future studies should use both larger samples of case companies with a possibility for quantitative analysis and, on the other hand, a more in-depth case study research design to explain in more detail the use of certain knowledge sources in certain phases of NPD and the integration of formal and informal knowledge into the NPD process.

In future studies, the theoretical sampling should be more exhaustive to determine the accurate relationship between the size of the company and the knowledge acquisition model. The identified knowledge acquisition models may also be related to the size of the organization, the industry, and the newness of the used technology. To understand multi-dimensional connections between knowledge acquisition models and the NPD process, future studies are needed in a variety of industries, in different size of companies, and in different technology areas as well as in the service industry.

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Appendix 1. Collected data

Company	Personnel in NPD	Interviewees	Questionnaires sent	Questionnaires returned
Company 1	2	Head of NPD unit	2	2
Company 2	3	Head of NPD unit and the CEO (together)	5	5
Company 3	9	Head of NPD unit (alone), Solutions director and product manager (together)	12	3
Company 4	9	Head of NPD unit	11	4
Company 5	5	Head of NPD unit	9	4
Company 6	7	Head of NPD unit	6	4
Company 7	3	Head of NPD unit	3	3
Company 8	3	Head of NPD unit (also the CEO)	4	3
Company 9	10	Head of NPD unit	10	4
Company 10	4	Head of NPD unit	12	8
Company 11	10	Head of NPD unit	10	10
Company 12	4	Head of NPD unit and two NPD engineers (together)	5	5
Company 13	4	Head of NPD unit	6	6
Company 14	15	Head of NPD unit	15	8
Total	88	19	110	69