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Knowledge management challenges in new business development: Case study observations

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Abstract

This paper's focus is on the *knowledge management challenges* that come along with technology-based new business development (NBD). NBD thrives upon the exploration of knowledge, under radical uncertainty. Furthermore, existing knowledge may both enable and constrain the radical innovation process. These characteristics make the dominant approach of knowledge management – focusing on codifying, collecting and distributing knowledge – unsuited for NBD. We suggest that knowledge management can enhance NBD by focusing on experimenting, monitoring and integrating knowledge. This is illustrated by case study observations of radical innovation processes.

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1. Introduction

The competitive landscape is changing rapidly. Different trends such as globalization, deregulation, blurring industry boundaries, technological convergence and disintermediation all pose new managerial challenges to large, incumbent companies (Prahalad, 1998). Similarly, radical technological innovations may threaten the strategic position of incumbents. The academic and professional literature has emphasized the role of new entrants in the creation of radical innovations (Abernathy and Utterback, 1978; Christensen, 1997; Henderson and Clark,

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1990; Tripsas and Gavetti, 2000; Tushman and Anderson, 1986; Utterback, 1994). It is often claimed that incumbent organizations have on average problems managing the industry turmoil stemming from the introduction of products based on radical innovations and may not be adept to manage the challenges and reap the business opportunities related to the emergence of disruptive or discontinuous technologies (Bower and Christensen, 1995; Christensen, 1997; Dougherty and Heller, 1994; Dougherty and Hardy, 1996; Leifer et al., 2000).

However, recent research suggests that large, established companies may actually be contributing to radical innovations to a much larger extent than what is generally assumed in the literature. Some large, incumbent companies embrace radical innovation as part of their strategy (Ahuja and Lampert, 2001; Chandy and Tellis, 2000; Methe et al., 1997; Rosenbloom and Christensen, 1998; Rothaermel, 2001; Hill and Rothaermel, 2003). These companies establish organizational mechanisms and routines that enable them to generate and successfully commercialize radical innovations (Ahuja and Lampert, 2001; Hill and Rothaermel, 2003). Why are these 'outliers' capable to profitably exploit non-traditional business opportunities and why are most other companies bound to their existing and maturing set of businesses? How can large companies get organized to tap into the potential of radical innovations? We suggest that part of the answer to these questions can be found in the way knowledge is managed within the process of new business development.

Our focus on knowledge management is in line with the recent recognition of the central role of knowledge in organizations by the fields of organization studies and innovation management. The knowledge-based theory of the firm (Winter, 1987; Kogut and Zander, 1992; Nonaka, 1994; Grant, 1996b) argues that organizational knowledge is a strategically important source of effective organizing. Especially the collective, situated and tacit nature of organizational knowledge makes it difficult to transfer, replicate or imitate and therewith a sustainable source of competitive advantage (Winter, 1987; Kogut and Zander, 1996). Given the importance of organizational knowledge, many companies have been trying to influence the creation, sharing and application of knowledge (e.g., Coombs and Hull, 1998; DeCarolis and Deeds, 1999; Von Krogh et al., 2001). Any systematic attempt in this direction can be labeled knowledge management (e.g., Davenport and Prusak, 1998). This case study will argue that traditional knowledge management approaches do not suit NBD. NBD poses specific challenges to knowledge management and we will suggest generic practices that can meet these challenges.

The empirical evidence in this paper comes from in-depth studies of radical innovation processes in three companies. First, the authors have been engaged in longitudinal collaborative research with DSM, a Dutch chemical company. In particular, the focus has been on the ideation, development and commercialization of business ideas by DSM Venturing & Business Development. Second, in 2001 a 6-month field study has been executed within Shell Global Solutions. In particular, the focus was on the OGIR group, which aims at providing Shell with innovative technological options for sustainable development in the areas of energy and mobility. Third, in 1999 an 8-month field study was executed within Philips Research, focusing on knowledge processes taking place in interactions between researchers. These studies were executed for a variety of objectives, but shared an interest in managing knowledge for radical innovation. Thus, for this paper we re-interpreted the case study evidence from the perspective of overcoming knowledge management challenges.

The paper is organized as follows. The next section explains how radical innovation and NBD fit into a corporate growth strategy and how they can be organized. Section three discusses the particular knowledge management challenges related to NBD based on radical innovations. We

argue that NBD is characterized by a need for exploration instead of exploitation, that it should deal with the enabling and constraining effects of existing knowledge and that knowledge management faces radical uncertainty. In section four we argue that the mainstream of knowledge management activities consists of externalizing, collecting and distributing knowledge within an organization, in order to make the most of existing knowledge. Instead of this exploitation strategy, which can be counterproductive for radical innovation (Coombs and Hull, 1998: p. 252), we propose an exploration strategy. Experimenting, monitoring and integrating are central practices in this exploration strategy for knowledge management in NBD. These practices and ways in which they can be realized will be discussed and illustrated by examples from NBD projects in DSM, Shell and Philips in Section 5. We draw conclusions in the last section.

2. Radical innovations and new business opportunities

Management of technological innovations is a key element in explaining the competitive successes and growth of companies (Conner and Prahalad, 1996; Kay, 1993; Roberts, 1999; Tidd et al., 2001). But technological innovations differ substantially from one another and, accordingly, have to be managed in different ways (Hill and Rothaermel, 2003). The matrix in Fig. 1 represents a familiarity matrix; the horizontal axis shows the familiarity within the company with the market, the potential customers, competitors and its raw materials. The vertical axis shows the fit with the technologies used by a company. The shaded area in the lower left corner of Fig. 1 represents the incremental and ongoing innovations that strengthen the firm's position in its current businesses. Most innovations in operational Business Units (BU's) are incremental and build on established products and technologies and exploit the current knowledge base of a company. They are mere improvements in the product to reinforce the current viability of the company in a particular business or market.

Contrary to incremental innovations, radical technological innovations are novel to the incumbent organization and require that the company develops new knowledge bases or that it recombines part of its established knowledge with newly developed knowledge (Freeman and Soete, 1997; Galunic and Rodan, 1998; Hill and Rothaermel, 2003). The return from radical innovations can be huge since they can be the enabler to outcompete competitors or to enter new

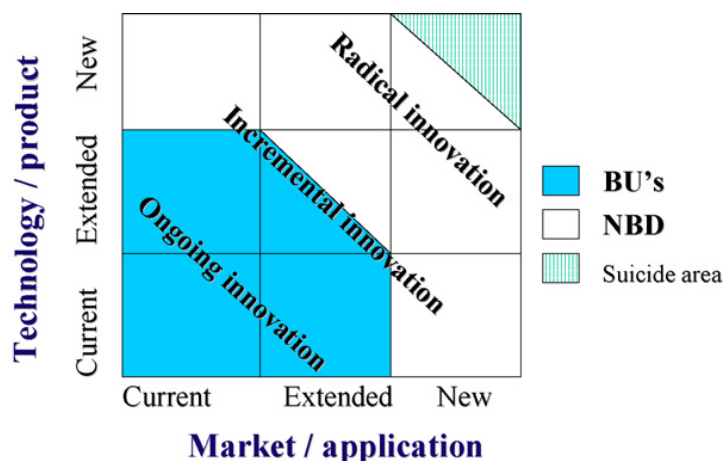


Fig. 1. Innovation in Business Units (BU's) and through New Business Development (NBD) (adapted from Ansoff (1957, 1965) and Roberts and Berry (1985)).

markets (Lynn et al., 1996). The downside is that the level of uncertainty is substantial: markets or applications for radical technologies are unknown, the technological feasibility is usually a major problem and forecasting sales is nothing more than a reasonable guess (Leifer et al., 2000; Lynn et al., 1996; Rice et al., 2001). Moreover, these high-risk initiatives can only be developed over a considerable period of time, sometimes 10–15 years in some industries such as the chemical and pharmaceutical industries.

An emphasis on incremental or ongoing innovations can be a valuable strategy as long as the competitive environment is stable and technological changes are competence enhancing. However, it is dysfunctional when a company faces a turbulent competitive environment or when disruptive technologies are emerging (Bower and Christensen, 1995; Lynn et al., 1996). Radical technological innovations may render the established knowledge base of incumbent firms obsolete and diminish the market value of a company's existing business portfolio. They turn existing competencies into 'core rigidities' (Leonard-Barton, 1992). Several scholars have argued that companies have to exploit current technology/market opportunities and explore simultaneously new technological and market-based opportunities (Cohen and Levinthal, 1990; Hamel and Prahalad, 1994; He and Wong, 2004; March, 1991; Morone, 1993; Tushman and O'Reilly, 1996). Balancing the exploitation of current knowledge and the exploration of new technological fields is critical to sustaining the long-term success of companies. Finally, the upper right triangle in Fig. 1 is often called the suicide area, since it is way too risky for a company to develop business opportunities based on innovations without a connection with the current market and technology employed within the company. Companies usually nurture this type of innovations by means of educational investments or explorative contract research (Roberts and Berry, 1985; Vanhaverbeke and Kirschbaum, 2003).

As it is not clear at the start which client markets might be interested in the product features and how the innovations might be applied in particular products to create customer value, radical innovations have a distinct nature and they obviously have to be managed in a different way than incremental innovations (Lynn et al., 1996). Business units (in many cases organized as profit centers with short-term financial targets) are essentially risk-averse and will only develop and commercialize technological innovations that have an incremental nature (Christensen, 1997; Tushman and O'Reilly, 1997). Business units with short-term profit responsibility will only approve R&D and product development that seeks to exploit existing or highly related technological competencies and market intimacy. Hence, developing the commercial potential of a radical innovation is completely at odds with the short-term business goals of the business groups within a company.

Exploring technology-based new business opportunities requires a different organizational setting. Drucker (1985) and Galbraith (1982) suggest that the tension between the short-term orientation of operational business units and the need to develop new businesses requires a structural separation between mainstream and newstream businesses. One possibility is that a company installs a separate and semi-autonomous unit to explore and nurture the commercial potential of radical innovations (Burgelman, 1985; Christensen, 1997; Roberts, 1980; Roberts and Berry, 1985; Tushman and O'Reilly, 1996: p. 25). Such separation ensures that each unit is configured to the specific needs of its task environment (Burns and Stalker, 1961; Lawrence and Lorsch, 1967) and benefits from the advantages of loosely coupled systems (Weick, 1976). However, autonomous units also have drawbacks (Birkinshaw, 1999; Birkinshaw and Gibson, 2004). Coordination costs increase because the frequent interaction with other parts of the company are harder to manage than in the case new ventures were initiated within an operational business unit. Autonomous units also risk to support ventures that are too far removed from the

strategy of the operational units or the corporate strategy. Therefore, several companies prefer to create new ventures only within the operational division to encourage a more commercial and responsive mind-set among its intrapreneurs (Birkinshaw, 2003).

3. Knowledge management challenges

The realization of radical innovations requires a different approach to knowledge management than the realization of incremental innovations and other organizational functions. This is due to three particular demands posed by NBD to the management of knowledge: (1) the emphasis on the exploration instead of the exploitation of knowledge; (2) the constraining effect of existing knowledge; (3) the radical uncertainty involved.

3.1. Knowledge exploration

The basic challenge for knowledge management in NBD is that its primary focus should be on the exploration instead of the exploitation of knowledge. Whereas exploitation consists of making the most out of existing technological, organizational and market knowledge, exploration consists of the pursuit of new fields of knowledge (March, 1991; Levinthal and March, 1993). In NBD, knowledge management should facilitate the exploration of new fields of technological knowledge, building up expertise in new markets and the creation of new competences. New technological capabilities are needed, or at least the stretching of existing capabilities (McDermott and O'Connor, 2002). Exploitation plays a secondary, supportive role in NBD. Exploitation is particularly important when new competences build upon existing competences and in the later stages of NBD projects, when new fields of knowledge crystallize.

Exploration is particularly challenging because knowledge and learning are subject to path dependencies. Path dependency means that future developments strongly depend upon past developments (David, 1985; Garud and Karnøe, 2001). Knowledge and learning exhibit the features that David (1985) identified as sources of becoming “locked in”: technical interrelatedness, economies of scale and quasi-irreversibility of investment. Pieces of knowledge are related and situated in a context, making it more difficult to explore new directions (Henderson and Clark, 1990; Lave and Wenger, 1991). Further, knowledge exhibits economies of scale as it does not deplete when it is used, therewith favoring the large-scale use of knowledge (Grant and Baden-Fuller, 2004). Finally, investments in learning and knowledge are quasi-irreversible, because knowledge acquisition takes much time. Each of these features makes that there is a tendency in organizations to stay on the beaten track and exploit existing knowledge in stead of exploring new knowledge.

3.2. Existing knowledge

The path dependence of knowledge and learning is associated with a second challenge: existing knowledge, cognition and learning may inhibit the creation of new technological paths. People and firms have a tendency to pigeon holing (Perrow, 1970), that is, to keep on doing the same in situations where that is not effective anymore. Working for years within a technological paradigm may make engineers ‘blind’ for other technological possibilities and constrain creative thought (Dosi, 1982; Moorman and Miner, 1997; Hill and Rothaermel, 2003). This is strengthened by the tight association of knowledge with identity (Brown and Duguid, 1991; Orr, 1990; Kogut and Zander, 1996). Organization members create their identities on the basis of what

they know how to do well. Deviating from existing knowledge domains therewith poses threats to the identity of an organization as well, as Cook and Yanow (1993) documented for one the world's most famous flute building companies. Furthermore, since learning is enabled by prior knowledge – absorptive capacity (Cohen and Levinthal, 1990) – there is an inclination to learn more in areas one is already familiar with. If this is not countered, people get trapped in existing learning trajectories and fail to learn in new areas (Levinthal and March, 1993). As a result, core competences may turn into core rigidities (Leonard-Barton, 1992).

3.3. Radical uncertainty

A third challenge is that the exploration of knowledge in NBD occurs under radical uncertainty. Organization scientists have traditionally defined uncertainty as a lack of information or knowledge (Galbraith, 1973; Tushman and Nadler, 1978). In NBD there is substantial uncertainty as to the technological feasibility and commercial potential of radical technological innovations. However, it is not just that organizations lack knowledge about markets and technological feasibility. Organizations aiming at NBD lack knowledge about what they need to know. An organization's lack of knowledge about its lack of knowledge is called radical uncertainty by Tsoukas (1996) and unforeseen uncertainty by De Meyer et al. (2002). Under radical uncertainty, it is not just that a map of a particular territory is lacking, it is also unclear what territories need to be charted. Before radical innovations have been developed and marketed, it is often unclear who the potential customers are (Lynn, 1998). The relevant markets do not yet exist. That makes it unclear what questions should be answered about the future market. Likewise, at the beginning of NBD, technologists do not know what knowledge they need to develop and during the process many unexpected questions will pop up.

These three challenges to knowledge management are most strong in the beginning of the NBD process. In the beginning of a NBD process, at the moment when it might even not yet be clear that what one is doing or thinking may turn into a NBD project, uncertainty is high. Uncertainty will even increase when ideas start to crystallize, since more and more problems will pop up. During the months and years that follow uncertainty decreases in NBD projects through several market and technology feasibility studies. As a result, they start to resemble incremental innovation projects. Of course, the amount of uncertainty is not monotonously decreasing, as unforeseen problems may occur and projects may turn into different directions as expected during the process. Comparable trends hold for the other two factors described above. The balance between exploration and exploitation of knowledge will shift to the latter in the course of NBD. More and more knowledge gets accumulated that needs to be retained and re-used. Correspondingly, existing knowledge will become more of an enabling factor instead of a constraint.

These changing conditions for knowledge management are related to the stages of NBD that are distinguished within some companies. For example, DSM applies a step-wise NBD-process with five stages: 'idea searching', 'idea evaluation', 'new business project', 'start-up company' and 'independent business unit'. A stage-gate process should be considered as a major organizational tool to bring down in subsequent steps the uncertainty level associated with radical innovations (Wheelwright and Clark, 1992; Cooper, 1993; Cooper and Kleinschmidt, 1995). In the early stages of NBD, the requirements for knowledge management are most extreme. In the later stages these requirements will be more alike the requirements for knowledge management in incremental innovation and other organizational activities.

4. Knowledge management for exploitation and for exploration

Most of the knowledge management literature and knowledge management practices have focused on the exploitation of knowledge, aiming at the effective and efficient use of existing knowledge (e.g., Anderson et al., 2001; Davenport and Prusak, 1998; Hansen and Haas, 2001; Becerra-Fernandez et al., 2004). It has flourished on the idea that knowledge has been underutilized within many companies. Such an underutilization of knowledge might be due to the inaccessibility of knowledge, the unwillingness to share knowledge or a lack of awareness about the existence of knowledge (sometimes expressed dramatically by managers: “If only we knew what we know!” (O’Dell and Jackson Grayson, 1998)). From an exploitation point of view, the ideal of knowledge management is to make all knowledge available to all organization members or, at least, to make the right knowledge available to the right persons at the right time (Davenport and Glaser, 2002; Hansen and Haas, 2001).

Three activities that are undertaken in order to reach that objective are externalizing, collecting and disseminating knowledge (e.g., Hansen and Haas, 2001; Selamat and Choudrie, 2004; Weiss, 1999). By externalizing knowledge it is attempted to make people’s personal knowledge explicit, to turn it into codified knowledge and to make it independent of any single person (Nonaka, 1994). Collecting externalized, codified knowledge at a central place – an intranet, database or library – is often seen as a prerequisite for making that knowledge accessible to others (Hansen and Haas, 2001). By ‘visiting’ this place where knowledge is collected, knowledge can be transferred to those who benefit by using it. Of course, explicit knowledge may also be transferred directly, without being collected first (Cummings and Teng, 2003). These activities form the outline of the ‘codification strategy’ as distinguished by Hansen et al. (1999).

Not all knowledge management literature focuses completely on exploitation and not only a codification strategy is promoted (Coombs and Hull, 1998; Von Krogh et al., 2001). An important alternative perspective is that of communities-of-practice (Lave and Wenger, 1991; Brown and Duguid, 1991), which is the prime example of a personalization strategy (Hansen et al., 1999). When such a personalization strategy is pursued, the focus is more on the third activity, disseminating, and less on the first two activities, externalizing and collecting. According to Brown and Duguid (1991), communities-of-practice also play a central role in innovation. However, they acknowledge that communities-of-practice are particularly suited for incremental innovation. Communities can improve and transform the practices they are centered on, but are less likely to come up with completely new practices. Radical innovation often occurs at the intersection of different communities (Van Looy and Debackere, 2001).

The knowledge management practices of externalizing, collecting and disseminating knowledge are unable to yield radically new knowledge, are unsuited to deal with uncertainties and ambiguities and may even reinforce existing path dependencies (Coombs and Hull, 1998). Especially in the first stages of NBD, three other basic activities are called for (see Table 1). First, instead of supporting the externalization of knowledge, an exploration approach supports

Table 1

Knowledge management activities for the exploitation and exploration of knowledge

Exploitation	Exploration
<ul style="list-style-type: none"> ● Externalizing ● Collecting ● Disseminating 	<ul style="list-style-type: none"> ● Experimenting ● Monitoring ● Integrating

experimentation. Whereas externalization makes knowledge independent from individuals, experimentation requires autonomous individuals. Second, whereas exploitation is enabled by the collection of knowledge, for exploration this is impossible or even counterproductive. Instead, emerging ideas and fields of knowledge should be monitored, not from a single perspective, but from multiple perspectives in the organization. Third, knowledge management for NBD should not (only) focus on the dissemination of knowledge, but on the integration of knowledge. These contrasting knowledge management activities for exploration will be further explained in the next section. As explained in the previous section, exploitation becomes more valuable in the later stages of NBD. That means that during the course of an NBD project the balance with shift from experimenting, monitoring and integrating to externalizing, collecting and disseminating knowledge.

5. Knowledge management practices for new business development

5.1. Experimenting

The development of new technological options cannot be a mechanical process. As Popper (1963) and other philosophers have stressed, there is no logic of discovery in the growth of knowledge. The development of new knowledge proceeds by trial and error, by variation and selection, by coming up with conjectures and testing them. In order to facilitate this process, knowledge management should support the experimentation with technologies and with markets (Von Krogh et al., 2001). Ahuja and Lampert (2001) found that experimentation with unfamiliar and emerging technologies enhances the chance on the creation of technological breakthroughs and radical recombinations of technologies. Further, experimentation can counter learning traps and blinders by providing experience in novel areas.

Technological experimentation can be facilitated in a diversity of ways. At Philips Research, researchers were encouraged to spend some of their time, about half a day a week, on topics not immediately related to their day-to-day work (Berends, 2003). They called this officially legitimized bootlegging work 'Friday-afternoon experiments'. These Friday-afternoon experiments are seen as a fertile way of generating options for new research projects. For example, one of the researchers told in the biweekly group work meeting that he had an argument with colleagues about the question whether it would be possible to make an ordinary transparency with the powder blasting technique he and his colleagues were working on. He argued that it should be possible, but his colleagues denied. So he tried to do it, he succeeded, and at the group work meeting he put the powder blasted transparency in the available projector and proudly showed the result to his group. Though this was not intended to be a worthwhile technological option to pursue, it is illustrative of an experimental approach.

At OGIR, the exploratory research group of Shell Global Solutions, one of the researchers was given the role of idea generator. This person had rejected an offer to become professor at a Dutch university, since he believed that he would never have the same freedom to explore whatever he liked as he had in his current function. Together with his assistant, this researcher was given the freedom to play around with ideas for the first time. One example illustrates their experimental style. They were working on a particular chemical process, which had not yet been used in industry since it proceeds very slowly, but would have huge potential if it could be accelerated. One of them brought sea water back home from his holiday. They tried to run the process in the milieu of seawater and this proved to speed up the process. This suggested that there were indeed options, not yet found of course, to speed up this process, and possibly commercialize it.

Not only should the development of technological knowledge be driven by experimentation, experimentation also plays a central role in the development of market knowledge (Rice et al., 2001). When pursuing radical innovation one cannot and should not simply 'listen to the customer', since it often not yet clear who the customer will be, and, moreover, potential customers have not yet experienced anything like it (Lynn et al., 1996: p. 11). In order to gain insight in market learning for discontinuous innovation, Lynn et al. (1996) studied four companies that realized a commercially successful breakthrough innovation. Lynn et al. found that each of these companies had been engaged in lengthy processes of probing and learning. They probed potential markets with early versions of a product, learned from those probes and probed again. Such probes can serve as vehicles to learn about the technology, but, more importantly, about potential applications and the appreciation of product features by users. At the same time, this may also create a niche for an application of the new technology.

Experimenting as a knowledge management strategy requires a different management style. Planning, command and control should be exchanged for an option-generating management strategy, characterized by autonomy and loose structures (McGrath, 2001; Hill and Rothaermel, 2003). This sets experimentation as a knowledge management activity clearly aside from externalization. Experimentation depends on individuals acting in relative freedom, whereas externalization aims at diminishing the dependence on individual organization members.

Experimentation often leads to ambiguous results and conflicting interpretations and not immediately to certain knowledge. Instead of striving after consensus and uncertainty reduction, NBD projects should foster conflicting beliefs, ambiguity, uncertainty and naivety. Organization members with conflicting beliefs are more likely to yield variance and creative solutions (Moorman and Miner, 1997). Moreover, any attempt at unanimity would be premature. When something does not work out the first time, should one abandon that strategy or repeat it, possibly with some modification? Empirical research by Garud and Van de Ven (1992) showed that in an ambiguous situation, with unclear goals and unclear means-ends relationships, the developers of cochlear implants did not adjust their actions when confronted with negative outcomes. This persistence is not irrational: few breakthrough developments are an instantaneous success. The acceptance of conflicting beliefs and ambiguous results resulting from experimentation fits exploration under radical uncertainty.

5.2. *Monitoring*

The second knowledge management activity for NBD is the monitoring of knowledge and knowledge development trajectories from multiple perspectives. Successful monitoring requires an active stance by managers and technologists. According to Rice et al. (2001), radical innovation is often hampered because managers do not recognize technical insights as opportunities. Managers should try to stay up-to-date on the ideas developed within their own organizations and evaluate whether these ideas might yield business opportunities. Besides, researchers and engineers should actively bring technological options to the attention of those that decide upon the formation of projects and new ventures. Few researchers will still embrace the belief that a 'good idea sells itself', but they often find out the hard way that more is needed to get support for their ideas than they had expected. Finally, technologists need to monitor technological options generated elsewhere in their organization. Radical innovations are often based on the re-combination of previously unrelated technologies (Galunic and Rodan, 1998). Under radical uncertainty, potentially valuable re-combinations are not known in advance, but need to be detected by creative researchers and developers.

There are several ways in which monitoring can be facilitated. For example, OGIR sends out a 20 page-long newsletter called “The Explorer” to 500 interested parties within Shell several times a year, describing projects and breakthroughs of OGIRs researchers. In this way, managers at different places within this large organization may learn about technological developments that may be used to develop new businesses in their area. Furthermore, OGIR was responsible for a Game Changer program, used to monitor for potential game-changing ideas present somewhere within Shell Global Solutions (see Hamel, 1999). Philips Research regularly organizes exhibitions where research groups present technological ideas, concepts and prototypes to the managers and the larger community of Philips. Internal colloquia may play a role in the monitoring process as well. Several types of colloquia exist at Philips Research in which technological ideas and research results are presented make these ideas known to a wider range of people, therewith enlarging the chance that they are recognized as valuable leads. Finally, informal conversations are an irreplaceable medium by which researchers and developers can keep an eye upon each other’s work and can observe potentially valuable recombinations of knowledge (Allen, 1977; Berends, 2003).

The value of monitoring internally can be illustrated by an example from DSM Chain Extenders. One scientist looked for several years for a way of increasing the speed on the polymerization of Polyamide 6, a core product for DSM. This project was about to be canceled, until DSM NBD picked it up. The innovative power was not that high for Polyamide 6, but proved to be much higher for Polyester and Polyamide 6,6. Before, these products had only been given a minor focus. By combining the market approach of NBD with the research knowledge of this person, a possible new business opportunity was created.

Monitoring should not be limited to internal developments. Past research in the field of innovation management has shown that many ideas and pieces of technical information come from sources outside the organization. For example, Langrish et al. (1972) studied the sources of the important ideas for the development of 51 Queen’s Award winning innovations. External sources provided 35% of these important ideas. It depends on the internal knowledge base and absorptive capacity (Cohen and Levinthal, 1990; Deeds, 2001) of those involved in NBD whether they can translate these external ideas into suitable new business ideas. This absorptive capacity can be increased by experimenting with new and unfamiliar technologies (Ahuja and Lampert, 2001). Keil (2002) and Chesbrough (2003) argue that external venturing becomes a crucial element in explaining the success of corporate entrepreneurship. New and promising technological breakthroughs are developed increasingly within start-ups, technical labs and universities. Even large companies have more and more problems in tracking new, relevant technologies and it is more efficient for them to monitor those technological developments through external venturing than developing these technologies in-house or within joint ventures.

DSM Melapur monitors developments in the flame-retardants markets in several ways. First, a weekly information bulletin, composed of industry articles by the Center of Information and Documentation, provides external information on the movements in the flame-retardants markets. Second, the requests for patents on flame-retardants, and thus the developments of competitors, are frequently analyzed. These sources have to assure that DSM Melapur knows what’s going on in the industry and can possibly take precautionary actions. These and other examples mentioned in this section show that collecting knowledge and ideas may play a supporting role in monitoring. However, this collection process should not be trusted too much, since ideas may be overlooked, interpreted from a single perspective and stripped from their context.

It is important that monitoring is an activity that is distributed over a range of managers and technologists. Monitoring from different perspectives makes it more likely that valuable new developments are detected. Organization members notice different things and develop diverging interpretations of observations. For example, at presentations it frequently happens that one of the attendants sees a possible re-combination that went unobserved by others. Monitoring from multiple perspectives diminishes the chance that ideas and experimental outcomes are judged by old and inadequate evaluation routines that are associated with an existing knowledge base. For example, the glue applied at 3M post-it notes was initially rejected because it was not sticky enough. However, it is precisely that characteristic that enabled the creation of the post-it notes (Garud and Karnøe, 2001).

5.3. Integrating

The third major knowledge management activity for the generation and commercialization of radical innovations is the integration of knowledge. The stretching of old competencies and the building of new competencies depend on knowledge integration (Grant, 1996a,b). No individual is capable of learning everything that is necessary to develop and produce complex products. Individuals have restricted learning capacities (Simon, 1991). The acquisition of knowledge requires that individuals specialize in specific areas of knowledge. Nevertheless, the development and production of complex products require the application of a wide range of knowledge (Demsetz, 1991; Grant, 1996b; Tsoukas, 1996). This fundamental asymmetry between knowledge acquisition and knowledge application has as a consequence that organizations have to integrate dispersed bits of specialized knowledge held by individuals. Thus, in order to build new competencies, pieces of knowledge created by experimentation and identified by monitoring should be integrated with each other and with existing knowledge and competencies. In the early stages of NBD, the integration of knowledge will have an experimental nature. New combinations of technologies can be considered as experiments. In later stages, when a NBD project is on its way or when new independent business unit is formed, knowledge integration should yield crystallized competencies.

As innovation often occurs at the boundaries of practices and communities, the integration of knowledge across these boundaries is especially important (Van Looy and Debackere, 2001). Boundary spanning activities are required to explore potential re-combinations of knowledge. Interacting with groups with different perspectives also increases the chance of overcoming the constraining forces of existing knowledge. These boundary spanning interactions for radical innovations need loose coupling, as radical innovation often changes interdependencies and interfaces between groups that are involved (Henderson and Clark, 1990).

Knowledge transfer or knowledge dissemination is often not a valuable strategy for knowledge integration. As Grant writes: “If Grant and Spender wish to write a joint paper together, efficiency is maximized not by Grant learning everything that Spender knows (and vice versa), but by establishing a mode of interaction such that Grant’s knowledge of economics is integrated with Spender’s knowledge of philosophy, psychology and technology, while minimizing the time spent transferring knowledge between them” (Grant, 1996b: p. 114). Likewise, marketeers do not need to learn what technologists know and vice versa. What is required for the concerted application of knowledge, however, is common ground (Grant, 1996a). The effective integration of knowledge requires mutual understanding and appreciation of each other’s contributions.

From the mid of the 1990s Philips Research has been working on PolyLED displays. This is a radically new display technology based on light emitting polymers, discovered in Cambridge in

1989. Several groups were involved in the development and pilot manufacturing of PolyLEDs, including chemical engineers, physical scientists and process operators. Effective organizing required that the knowledge inputs from these different groups were concerted. For example, the process operators had to learn what coating problems could be solved by the chemical engineers and what problems required the expertise of those with a scientific background in physics. In such a situation the critical knowledge management task is not the transfer of knowledge from one group to the other, but the integration of the fields of expertise and the specific ideas of these different groups.

6. Conclusion

Large diversified companies usually do not have good track records in managing discontinuous change and in turning breakthrough innovations into long-term growth and profit engines. But there are many counterexamples. Most companies that successfully manage to turn radical technological innovations into new businesses are experienced in corporate venturing and new business development. In this paper we have analyzed the knowledge management challenges faced by these companies that rejuvenate their business portfolio through NBD.

NBD is a complex process and the knowledge management challenges are considerable: NBD requires the exploration instead of the exploitation of knowledge, under radical uncertainty and with existing knowledge as a constraint as well as an enabling factor. Due to these challenges, NBD activities require a different approach to knowledge management than the one predominantly advocated in the literature. The mainstream of the knowledge management literature and practice focuses on the exploitation of knowledge by externalizing, collecting and disseminating knowledge. In contrast, an exploration approach to knowledge management in order to support NBD should focus on experimenting, monitoring and integrating. Experimentation may be facilitated by providing time and resources for experimenting with new technologies, creating loose structures, tolerating uncertainty and ambiguity and actively probing markets. Monitoring may be enhanced by keeping others up-to-date on internal developments through newsletters, exhibitions, colloquia and informal conversations, scanning the environment, for example through patent analysis, and employing the attention and detective capabilities of a wide range of employees. Finally, knowledge integration for exploration may be facilitated by enhancing loose connections and boundary spanning activities.

However, there is also a supportive role for exploitation in radical innovation. Without knowledgeable researchers, engineers, project managers and marketeers radical innovation is impossible. What is important, though, is that existing knowledge is bracketed, questioned and re-combined in new ways and not treated as a foundation to build upon. Through such a detached attitude toward existing knowledge, in combination with the activities suggested above, radical innovation can benefit from existing knowledge while minimizing its constraining effect. During the process of NBD uncertainty decreases and the balance between the need for exploration and for exploitation shifts towards the latter. The conditions for knowledge management become more similar to those in incremental innovation and other business activities. This implies that in the course of an NBD project, the emphasis has to shift from experimenting, monitoring and integrating to knowledge management activities that are oriented at exploitation.

This paper has some clear limitations. It is based upon qualitative analysis observations in three corporations. Additional qualitative case studies are needed to identify whether other companies have found alternative ways to realize experimentation and the monitoring and integrating of knowledge. Furthermore, quantitative studies are needed to ascertain whether the

three generic practices discussed in this paper indeed positively impact radical innovation processes and compare this effect with the effect of the 'traditional' practices of externalizing, collecting and disseminating knowledge.

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