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Knowledge management challenges in corporate venturing and technological capability building through radical innovations

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Abstract

This paper’s focus is on the knowledge management challenges that come along with technology based corporate venturing (CV). CV is a complex process including internal, joint and external venturing. It can be organized into a (semi)-autonomous business unit. This unit manages CV-projects through a sequence of subsequent stages starting from high risk and low stakes in the idea evaluation to lower risk and higher stakes in pilot plant production at the start-up company. These consecutive steps can be considered as a sequence of option payments over time in a technology.
CV activities require a different approach to knowledge management that is predominantly focused on codifying, collecting and distributing knowledge. Knowledge management can enhance CV by focusing on experimenting, monitoring and integrating. As a result, knowledge management requires a contingency approach tailoring knowledge management activities to the specific tasks of the CV.

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1. Introduction

Radical or ‘breakthrough’ innovations constitute an important source for entrepreneurial activities within companies. The academic and professional literature has focused mainly on the role of new entrants in the creation of radical innovations (Abernathy and Utterback 1978, Christensen 1997, Henderson and Clark 1990, Tripsas and Gavetti 2000, Tushman and Anderson 1986, Utterback 1994). 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 (Mete et al. 1997, Ahuja and Lampert 2001, Rosenbloom and Christensen 1998, Rothaermel 2001, Hill and Rothaermel 2003).

Companies that successfully managed to turn radical technological innovations into new and profitable businesses have been involved in corporate entrepreneurship on a continuous base (Hitt et al. 2002). Business units (in many cases organized as profit centers with short-term financial targets) are essentially risk-avers and will only develop and commercialize technological innovations that have an incremental nature (Christensen, 1997, Tushman and O’Reilly III, 1997). Corporate entrepreneurship, organized into a dedicated and (semi-)autonomous new venture or new business development unit (NBD), can be considered as an attempt of large companies to nurture, develop radical innovations as the initial phases to create new businesses (Burgelman, 1985; Roberts, 1980; Roberts and Berry, 1985). It is the pursuit of technology based economic opportunities beyond the current competencies of the company: competence building is intrinsically linked to corporate venturing (CV) or new business development (NBD) activities.

This paper’s focus is on the knowledge management challenges that come along with CV or NBD activities. Recent literature in the fields of organization studies and strategic management has recognized the central role of knowledge in organizations. It has been argued that knowledge and competences are a source of effective organizational actions and competitive advantage (e.g. Winter 1987). Given the importance of knowledge as a source of efficient and effective actions and competitive advantage, it is understandable that many companies have tried to influence knowledge processes. Knowledge application, knowledge sharing and knowledge creation are most often mentioned as central knowledge processes (e.g., Coombs and Hull 1998; DeCarolis and Deeds 1999; Von Krogh et al. 2001). Knowledge management can be defined as any attempt to influence these processes (e.g. Davenport and Prusak 1999).

New Business Development and other Corporate Venturing activities pose particular challenges to knowledge management. When aiming at radical innovation, a company is faced with radical uncertainty (Tsoukas 1996). This implies that a company lacks knowledge, and, moreover, does not even know which knowledge it lacks. In addition to that, existing knowledge may even hamper the development of radically new knowledge. This implies that
CV requires a different approach to knowledge management than most other organizational activities. The mainstream of knowledge management activities consists of codifying, collecting and distributing knowledge within an organization, in order to make the most of existing knowledge. We argue in this paper that CV requires another set of knowledge management activities: experimenting, monitoring and integrating. These activities and the way in which they can be realized will be illustrated by examples from CV-projects in DSM, Shell, Philips, ASM and other companies.

The paper is organized as follows. The next section describes how some large companies that are experienced in corporate venturing successfully turn radical innovations into profitable businesses. We focus on how CV fits into a corporate growth strategy and how it can be organized. Furthermore, we take the example of a Dutch chemical company to illustrate the organization of CV activities. Sections three and four discuss the knowledge management challenges related to CV based on radical innovations. Experimenting, monitoring and integration of knowledge are the three knowledge challenges that are discussed in detail. Finally, we draw conclusions and make suggestions for future research in a concluding section.

2. Radical innovations and new business opportunities

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 2002). Similarly, radical technological innovations may threaten the strategic position of incumbents (Abernathy and Utterback 1978, Christensen 1997, Henderson and Clark 1990, Tripsas and Gavetti 2000, Tushman and Anderson 1986, Utterback 1994). 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 streams (Freeman and Soete 1997). 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 1995).

Incumbent organizations have on average problems managing the industry turmoil stemming from the introduction of products based on radical innovations. They are not 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). But some scholars found evidence that this tendency is not universal and that some large, incumbent companies embrace radical innovation as part of their strategy (Methe et al., 1997, Ahuja and Lampert 2000, 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). There are companies that managed to grow profitably through new business development that requires the building of new competencies.

These exceptions or counterexamples prove that large incumbent companies have the potential to build new technological capabilities based on newly emerging (and disruptive) technologies and that they know how to convert discontinuous technological innovations into competitive advantage in existing or new industries, applications or markets. There are
companies that managed to grow profitably through new business development that requires the building of new competencies (Ahuja and Lampert 2001, Leifer et al. 2000, Methe et al. 1997, Rosenbloom and Christensen 1998, Rothaermel 2001, Hill and Rothaermel 2003). Why are these ‘outliers’ behaving in a different way than the average incumbent companies? Why do they embrace radical innovations as a mean to renew the company and bolster their competitive position in existing and new product markets? What are the organizational and managerial prerequisites to learn from distant technological fields and to develop completely new capabilities?

We focus in this section on corporate venturing and new business development as one particular way how a company can get organized to develop new technological competencies and to build a strong competitive position in new markets or applications.

2.1 Organizing incremental and radical innovations

Management of technological innovations is a key element in explaining the competitive successes and the growth strategies of companies. But technological innovations differ substantially from one another and, accordingly, have to be managed in different ways. Most innovations are incremental and build on the established knowledge base of a company. They are mere improvements in the product to satisfy profitably the customer needs. Radical innovation, on the contrary, explores technology areas that are novel to the innovating company and requires the development of new technology bases. 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, Leonard-Barton 1995, March 1991, Tushman and O’Reilly 1996).

Incremental and radical innovations differ in many aspects. Radical innovations are promising: they may allow a company to outcompete competitors and to enter new markets. The backside is that the level of uncertainty is substantial: markets or applications for a new, radical technologies are unknown, the technological feasibility is usually a major problem and forecasting sales is nothing more than a reasonable guess. So, how can large companies get organized to tap into the potential of radical innovations?

2.2 Corporate venturing as part of the growth strategy

Companies have to exploit the current knowledge base and to explore the possibility to develop new ones simultaneously in order to guarantee a sustainable profitable growth (March 1991, Tushman and O’Reilly 1996). As a result, corporate initiatives to explore business opportunities based on new technologies always have to be fully integrated as part of an overall corporate growth strategy.

A corporate growth strategy takes different forms depending on the strategic targets. First, we look at the expansion of existing businesses: a company usually grows through organic growth based on accumulated investments and company based R&D. Growth can of course also be realized through an sustained acquisition strategy; market share and technological capabilities are acquired from target firms which are managed to become a integrated part of the company after a post-acquisition integration process. Business units usually play an important role in the growth strategy of existing businesses and markets.
Exploring technology based new business opportunities requires a different organizational setting. Many multi-business companies have decentralized profit and loss responsibility to the business unit level in order to spur the market responsiveness and to reduce time-to-market when introducing new products into the market (Ghoshal and Bartlett 1997). Decentralization of responsibility allows business unit managers to apply their resources more efficiently to new market opportunities and technological developments that could add value for (potential) customers (Bartlett and Ghoshal 1993). The backside of this trend towards decentralization is that 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. Business units will spontaneously overemphasize ongoing and incremental innovations because of the low risk involved, the relatively short development time and the opportunity to deepen the existing, in-house expertise.

This 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). When companies only invest in sustaining their current technologies and competencies, they face considerable problems in redirecting the focus on emerging, non-traditional technologies (Christensen, 1997). New competencies learned in anticipation or in response of the changing competitive context, but that requires that companies invest in breakthrough ideas and in corporate entrepreneurship. As existing businesses have strong incentives to invest only in incremental innovations, the development of radical innovations into new businesses has to be cultivated on the corporate level. If companies are not able or willing to do so, strategic inertia emerges in the face of innovative opportunities and their core competencies might turn into core rigidities (Leonard-Barton 1992 1995)

Some firms manage to grow through a strategy of starting up new businesses based on radical technologies that have been turned into a commercial success. Why are these companies capable to profitably exploit non-traditional business opportunities – we look more specifically at opportunities based on radical technological innovations – and why most other companies are bound to their existing and maturing set of businesses? Part of the answer is that the former build new technological competencies though corporate initiatives in order to start-up and develop technology enabled new business opportunities. One of the common routes to corporate growth and renewal is corporate venturing. We illustrate this in figure 1 with the ‘new business development’ strategy of DSM, a Dutch multinational in the chemical industry.
Ongoing and incremental innovation builds on current products and technologies. It often requires the exploitation of current knowledge to further refine the existing product portfolio. It is often used to strengthen or reinforce the current viability of the company in a particular business or market (March 1991). Exploring the business opportunities related to radical innovations is often associated with new business development (NBD) or corporate venturing (CV) (McGrath and MacMillan 2000). It is essential for a sustainable and profitable growth strategy to find a balance between the exploitation of current knowledge and the exploration of new fields of interest. The matrix in figure 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 figure 1 represents the incremental and ongoing innovations that strengthen the firm’s position in its current business. Business units usually take the initiatives given the low risk profile of these innovations and the short-term pay-off. These innovations follow the short-term results orientation followed by most business units. Although these innovations are essential to maintain a leadership position in current markets, an overemphasis on incremental innovations endangers the future of the company. Morone, (1993) has shown that US firms that have succeeded in head-to-head competition against Japanese firms in electronics-related markets found that the US successes were built on a combination of discontinuous innovations and incremental improvements. Their competitive advantage was build on the basis of risky, failure-laden, expensive and time-consuming efforts to pioneer new businesses. They sustained this advantage over time through

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1 We could also call this ‘new product innovation’
incremental product line improvements and extensions. This shows clearly that a balance of both incremental and radical innovations is critical to a sustained long-term success.

The upper right triangle in figure 1 is often called the suicide area. It is essential for a company to keep out of this type of innovations. Because there is no connection with the current market and technology employed within the company, it is way too risky for a company to develop business opportunities based on these innovations. However, a company can always get involved in educational acquisitions or venture capital funds to keep a window on the technology (Roberts and Berry 1985).

CV can be defined as “the development of new, radical products which are synergetic to the company’s technologies and markets, but hold the promise of evolving into new businesses for the company”. This definition includes two key factors. First, the new product is to provide synergy with the current markets or technologies served by the company. The familiarity of a company is a critical variable that explains much of the success or failure in NBD (Roberts and Berry 1985). Hence, radical innovations do not stem from technologies that are highly unrelated to the existing technological capabilities of the company. Fit with corporate strategy plays an important role in the selection of new business projects (Vanhaverbeke and Kirschbaum 2002). This implies that CV or NBD is always to some extent related to the to the company’s current technologies or to the markets it is serving – see white area in figure 1.

CV should hold the promise to provide potentially new businesses to the company. Companies need CV to create a new business opportunities and to secure the overall profitability and growth of the company. Radical innovations are also necessary to preempt innovative competitors or new entrants (Parkes 1995). Next, the development of new businesses is essential for the rejuvenation of the company’s product portfolio and it can possibly create new technological capabilities for companies which are crucial to secure the firm’s competitiveness in future (Kirschbaum and Schaaftsma 1997, Leonard-Barton 1995, Vanhaverbeke and Kirschbaum 2002).

In CV a company can move further away from their core competencies in markets and/or technologies. This implies that in CV there is substantial uncertainty as to the technological feasibility and commercial potential of radical technological innovations. Only a few of the many interesting technological inventions are turned into a new profitable business. It is not uncommon that hundreds of new ideas get killed before one innovation hits successfully the market (Foster 1986, Freeman and Soete 1997, Rogers 1995). Moreover, these high-risk initiatives can only be developed over a considerable period of time, sometimes 10 to 15 years in different industries. The time-horizon to build up knowledge about the potential markets and the further development of the technologies involved is much longer than in the case of incremental innovations. Consequently, there is also more “patient money” to be invested and it is very likely in traditionally managed companies that deteriorating short-term financial performance will drive the organization to kill first projects that do not directly contribute to the success of the current businesses (Rice et al., 1998).

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. 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. They are interested in short-term profit seeking, incremental
innovations and the exploitation of current knowledge. A company has to install a separate and semi-autonomous unit if wants to explore and nurture the commercial potential of radical innovations. A new autonomous unit charged to commercialize radical innovations typically benefits from the advantages of loosely coupled systems (Weick 1976).

2.3 Organizing the corporate venturing process

Corporate entrepreneurship can be organized in different ways and corporate venturing is only one of them. (Hitt et al. 2002)². In a distant past, CV was restricted to the technical development and commercialization of a few radical innovations that had originated in the R&D labs of the company. However, as technological pace and complexity is increasing companies have to complement internal R&D with external acquisition of technology through alliances and acquisitions (Granstrand et al. 1992, Lambe and Spekman 1997). Technological learning is more and more based on a combination of internal and external learning and both types of learning are considered to be complements reinforcing each other’s productivity (Cohen and Levinthal 1990, Duysters and Hagedoorn 2000).

The need to tap into technology sources outside the company is reflected in the way CV is nowadays organized in some large diversified companies. They divide CV into internal, joint and external corporate venturing. Joint-ventures were fashionable in the eighties and nineties. External ventures are participations in strategically selected venture capital funds and direct participations in promising start-ups. Venture-capital funds have a financial focus, but large (industrial) corporations invest in start-ups because of their strategic value: they spin-in start-ups that fit maximally the explorative research areas of the company.

External venturing has several advantages and will become even more important in the future for the following reasons. First, the number of radical innovations developed by small start-ups in emergent technologies and the number of spin-offs from universities is increasing. Next, external venturing allows a company to sense and monitor, firsthand, new technologies and applications and to have a window on the latest technological developments. Finally, apparent time to market shortens when a company can spin in a promising venture compared to the situation in which it has to commercialize an innovative idea from scratch. External venturing is valuable when radical innovations represent technological fields or applications areas that are completely new to the company (the so called ‘suicide area’ in figure 1) and that have a low probability of success. Roberts and Berry (1985) argue that companies should avoid large-scale entry in this situation. They recommend companies to build familiarity with the new area through (inexpensive) venture capital or educational investments. Over time, the investing company will get a better understanding of the potential success of the new technology. It has the option to eventually spin-in the venture when familiarity with the technology is sufficiently strong and the venture proves to be promising.

Some companies recognize that new business development and new competence learning should be managed in an integrative way. DSM, a Dutch specialty chemicals and materials company with annual sales of EUR 6.7 billion and a worldwide employment of 18.500 in 2002, reorganized its new business development activities and external venturing into a single business group, called ‘DSM Venturing & Business Development’ (DSM V&BD). The business group is actively involved in new business development (internal corporate

² This paper focuses exclusively on the corporate venturing process but there are several other ways to spur and institutionalize corporate entrepreneurship (Ghoshal and Bartlett 1997, Hamel 1996).
ventures), investments in Venture Capital Funds (VCFs) and in promising start-up companies (external venturing), and equity and non-equity alliances with universities and companies with complementary technologies or other intangible assets such as knowledge about and manufacturing expertise.

‘DSM Venturing’ – the venturing unit within V&BD - is not working as a typical VCF. Its objective is to spot technology based business opportunities in DSMs strategic growth fields, i.e. ‘Life Science Food Ingredients’, ‘Life Science Pharma’ and ‘High Performance Materials’. In these fields DSM Venturing is eager to have a window on the world, seeing new technologies and business models and to create strategic relations between the company and start-ups in order to create mutual value. Once the technical feasibility and market opportunities become tangible – i.e. once the uncertainty is pulled down to an acceptable level – the company turns the monitored new technology into a sustainable business within a time span of a few years. During this period the business may be developed as a new operational business unit in the company or a spinout outside DSM depending on the fit with DSM's vision and strategic growth.

New product development and corporate venturing easily suffer from several problems. The failure rates of innovation projects introduced as commercial products are extremely high. Between 33-60% of all new products that reach the market place fail to generate an economic return (Schilling & Hill, 1998). Research and business practice have tried to improve these failure rates by looking at the success factors underlying new product development. One clearly identified success factor throughout these studies is the use of a structured development process. Other success factors associated with this process are the quality of execution of the activities in the process, fast-paced parallel processing, completeness in pursuing these activities and a clear emphasis on the market side of new product development (Cooper 1993, Cooper and Kleinschmidt 1995, Kleinschmidt and Cooper 1995, Lester 1998, Montoya-Weiss and Calantone 1994).

NBD and CV consist of diverse activities that have a mutual impact on each other. Developing new businesses based on radical innovations requires new skills and competencies, the exploration of new markets or business models, the development of systems and routines that can be rolled out to each new NBD-project with relative ease. New NBD-projects are the ‘carriers’ to sense, explore and develop possible new business opportunities. We suggest that NBD-projects based on internally developed radical innovations and CV-projects based on externally acquired innovations can be managed successfully into a potential new business if the company pays attention to the crucial knowledge requirements in that process. We enter this topic in the following section.

3. Knowledge management challenges

In the distant past, some scholars in organization science recognized the value of knowledge and expertise in organizations. But knowledge and knowledge processes in organizations have only received systematic theoretical and empirical attention during the last decade. Knowledge has become a central concept in the field of organization studies (e.g., Nonaka 1994; Grant 1996b). The prime contribution of knowledge is that it enables actions. Epistemologists have considered knowledge to consist of (a subset of) true beliefs about the world (Goldman 1999). If a chemical engineer has a correct belief about the effectiveness of a catalyst, he is enabled to design a productive process. If someone has a correct belief about
the cause of a particular quality problem in production, he is in a better position to solve that problem. Without such knowledge he is left in the dark. Knowledge can be compared with an accurate map of a district. Having a map of the territory in which we want to travel, gives us the coordinates of the places we want to go and routes to get there. The map enables efficient traveling and avoids moving around by trial and error. Having more knowledge than competitors may therefore provide a competitive advantage to a firm.

The knowledge-based theory of the firm (KBT) uses knowledge and knowledge processes to explain the existence, structure and performance of organizations (Kogut and Zander 1992; Grant 1996a; 1996b). It stresses that specific characteristics of organizational knowledge make it the more valuable as a source of competitive advantage. The KBT emphasizes the collective characteristics of knowledge in organizations. Theorists of the KBT argue that the capabilities of an organization reside not only in the knowledge of individuals, but particularly in the way this knowledge is integrated. The collective nature of these organizational capabilities makes them difficult to transfer, replicate or imitate. This is enhanced by the fact that the need for knowledge integration makes organizational knowledge idiosyncratic and situated (Brown and Duguid 1998). Furthermore, it is especially the tacit component of capabilities that makes them a source of competitive advantage (Winter 1987). Tacit knowledge is that knowledge that we use unconsciously when we take conscious actions or apply explicit knowledge (Polanyi 1958). Tacit knowledge is difficult to transfer, observe or sell. Capabilities built on tacit knowledge are therefore hard to replicate by others. Competitive advantage based on such collective, situated and tacit capabilities has a higher chance of being sustainable.

We focus in this paper on the knowledge management challenges that come along with NBD and other CV activities. A first knowledge management challenge in CV is to accept ‘radical uncertainty’. When aiming at CV, not all required knowledge is available in the company. Since CV consists of the development and deployment of new technologies, existing technological knowledge does not suffice. New capabilities are needed, or at least the stretching of existing capabilities (McDermott and O’Connor 2002). Moreover, organizations aiming at CV lack knowledge about what they need to know. Tsoukas (1996) labeled this ‘radical uncertainty’. This holds as well for technological knowledge as for knowledge about markets or applications. Knowledge on markets is lacking as well, since these markets often do not yet exist. With respect to radical innovations, even customers do not know what they might want in the future (Lynn 1998). Moreover, before radical innovations have been developed and marketed, it is often unclear who the potential customers are. Technological discontinuities come along with a high degree of uncertainty about markets (Tushman and Anderson 1986: 455).

Under radical uncertainty, it is unclear what ends are fruitful to pursue, let alone that it is clear how to get there. It is not just that a map of a particular territory is lacking, it is also unclear what territories would need to be charted. Nevertheless, the stakes are high and some routes may prove to be valuable and others dead-ends.

We mentioned already that economic, strategic and organizational factors have been found to strengthen the tendency of incumbents to follow existing technological trajectories. From a knowledge management perspective, it is especially noteworthy that a subset of organizational factors, relating to knowledge, cognition and learning, may inhibit the creation of new technological paths. This is another challenge for knowledge management in CV activities. According to Dosi (1982: 153) path dependence is associated with engineers
becoming ‘blind’ for other technological possibilities. This has been addressed by concepts like pigeon holing (Perrow 1970), core competences that turn into core rigidities (Leonard-Barton 1992) and learning traps (Levinthal and March 1993). These concepts point at the tendency of persons and firms to keep on doing the same in situations where that is not effective anymore. Knowledge that was relevant for existing technologies and adequate for existing markets, may prove to be inadequate for new technologies and markets and constrain creative thought. This is strengthened by the tight association of knowledge with identity (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. Moorman and Miner (1997) confirmed that in a quantitative study that existing knowledge may prove to be a constraining force on radical innovation.

The remarks made above imply that corporate venturing is a peculiar setting for knowledge management. Instead of finding knowledge, waiting to be ‘managed’, one is faced with radical uncertainty. Moreover, existing knowledge may even be a burden. Coombs and Hull (1998: 252) suggest that knowledge management practices may reinforce existing path dependencies. Nevertheless, they hypothesize that knowledge management may also increase the capability of an organization for variety generation. This suggests that that CV requires a different approach to knowledge management than many other organizational activities.

A broad distinction can be made between knowledge management that is oriented at the exploitation of knowledge and knowledge management that is oriented at the exploration of knowledge. Most of the knowledge management practices and literatures have focused on the exploitation of knowledge. Von Krogh et al. (2001) called such a focus a ‘leveraging strategy’. It focuses on the effective and efficient use of existing knowledge. It has flourished on the idea that knowledge has been underutilized within many companies. The major reason provided for this underutilization is a lack of, or not enough, knowledge sharing. A lack of knowledge sharing might lead to attempts to reinvent wheels and inadequate coordination (Bender and Fish 2000; Hoopes and Postrel 1999). Such an underutilization of knowledge might be due to the fact that people are unaware about of the existence of knowledge, sometimes expressed dramatically in the saying by CEOs: “If only we knew what we know!” (O’Dell and Jackson Grayson 1998). The origin of such problems lies among others in the tacit nature of much organizational knowledge. That makes it the more difficult to detect and transfer. Knowledge management that is focused on the exploitation of knowledge typically aims at codifying, collecting and disseminating existing knowledge in order to make all knowledge available to all organization members. Actions may include the externalization of knowledge, attempts to make people’s personal knowledge explicit and turn it into codified knowledge and the storage and distribution of this codified knowledge via databases and intranets. But such an exploitation strategy is not necessarily refined to a ‘codification strategy’ (Hansen et al. 1999). The exploitation of knowledge can also be enhanced by the deployment of a ‘personalization strategy’, for example via the creation of communities-of-practice or the introduction of competence-management. Though knowledge management is typically introduced as a typical feature of the so-called knowledge economy, this exploitation strategy is remarkably similar to early scientific management ideas. Almost a century ago, Taylor (1916) wrote: “The first of the great principles of scientific management (...) is the deliberate gathering together of the great mass of traditional knowledge which, in the past, has been in the heads of the workmen, recording it, tabulating it, reducing it in most cases to rules, laws, and in many cases to mathematical formulae (...).”
However, this traditional knowledge management strategy of externalizing, collecting and disseminating existing knowledge in order to make all knowledge available to all organization members is not adequate for CV. CV requires a knowledge management strategy that is focused upon exploration. Exploration involves path creation instead of path dependency (Garud and Karnoe 2001). In CV the knowledge management focus should be on the creation of knowledge. Instead of externalizing, collecting and distributing, an exploration approach to knowledge management calls for \textit{experimenting}, \textit{monitoring} and \textit{integrating}. These three activities will be discussed below.

4. Knowledge management activities for Corporate Venturing

4.1. 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. In science this consists in coming up with conjectures and testing these hypotheses. In technology it is also about coming up with ideas on new technological principles. Von Krogh et al. (2001) suggest ‘probing’ as a knowledge management strategy for the development of new knowledge in a new domain. Knowledge management should support experimentation with technologies and with markets. Ahuja and Lampert (2001) found that the experimentation with unfamiliar technologies, emerging technologies and pioneering technologies enhance the chance on the creation of technological breakthroughs. Experimentation can counter learning traps and blinders by providing experience in novel areas. Moreover, the experimentation with emerging and pioneering technologies is more likely to provide opportunities for radical technological breakthroughs and radical recombinations of technologies. Experimentation is oriented at the creation of variety. Instead of striving after consensus and uncertainty reduction, CV projects should foster conflicting beliefs, ambiguity and uncertainty and naivety. These are more likely to yield variance and creative solutions (Moorman and Miner, 1997). Further, 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 goal autonomy and ambiguous structures (McGrath 2001). Of course, this should not lead to limitless freedom as we have argued before. CV activities should be aligned with the corporate strategy and be put under attention in contact with top-management for the selection of projects.

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). This officially legitimized bootlegging work was labeled ‘Friday-afternoon experiments’. These Friday-afternoon experiments are seen as a fertile way of generating options for new research projects. For example, in the biweekly group work meeting Paul, a researcher, tells 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

\footnote{Names have been changed in order to protect anonymity.}
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. In several other cases such Friday-afternoon experiments did lead to new research projects.

At OGIR, an 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 freedom to explore whatever he liked as he had in his current function. This person was given the freedom to play around with ideas for the first time. One example illustrates his experimental style. While reflecting about a well-known chemical process, that had not yet been commercialized since it proceeds a very slowly, his assistant brought regular sea water back home from his holidays. 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 can also play a central role in the development of market knowledge. 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: 11). Companies in the study of Lynn et al. (1996) 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.. Rice et al. (2001) notice that early prototypes and a range of possible applications enlarge the options for market experimentation.

However, experimentation or probing often leads to ambiguous results. In an unfamiliar situation, it is very difficult to learn something with certainty. When something does not work out a 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. Such a persistency is not irrational: few breakthrough developments are instantaneous successes. Radical innovation requires endurance. However, with hindsight, in the cochlear implants case it would have been better to experiment with a broader range of technological options, since the option that was focused on did not become a success. Another danger of experimentation is that of both experimenting and monitoring is that outcomes are judged by old and inadequate evaluation routines. 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 Karnoe 2001). In general we can say that experimentation does not immediately lead to certain knowledge. Resulting knowledge is of an exploratory nature – perhaps not even worthy of the name knowledge when the strict epistemological criteria of truth and justification would be applied (Goldman 1999).

**4.2. Monitoring**
Another knowledge management task in corporate venturing is the monitoring of knowledge and knowledge development trajectories, both internally and externally. Part of the need for monitoring consists in the observation and evaluation of technological ideas and concepts developed internally. According to Rice et al. (2001), radical innovation is often hampered because technical insights are not recognized as opportunities by managers. They called this the initiation gap. Successful monitoring requires an active stance by technologists as well as managers. 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. On the other hand, 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.

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. After several projects and successful tests, this product was about to be canceled, until DSM NBD picked it up. The innovational power was not as much in Polyamide 6, but moreover in 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 has been born.

There are several ways in which monitoring can be facilitated. OGIR, the exploratory research group of Shell Global Solutions, sent out a 20 page-long newsletter to 500 interested parties within Shell several times a year, describing findings of OGIRs researchers. In this way, managers at different places within this large organization may learn about technological developments that might be used to develop new businesses in their area. At Philips Research exhibitions are organized regularly, at which research groups present technological ideas, concepts and prototypes to the managers and larger community of Philips. Internal colloquia may play a role in the monitoring process as well. Several types of colloquia exist at Philips research. On the one hand, lectures 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. On the other hand, colloquia may serve to translate ideas. It happens frequently that an idea that is presented with regard to a particular problem is recognized as being applicable to another type of problem as well. Of course, several other strategies for the monitoring of internal knowledge development can be envisioned and found.

Monitoring should not be confined to the monitoring of internal developments. First, 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 Myers and Marquis (1969) found in a large but detailed study of 567 innovations in the railroad, housing and computer industries that 52 percent of information used stemmed from internal sources and 35 percent from external sources. Langrish et al. (1972) report about the sources of the important ideas for the development of 51 Queen’s Award winning innovations. Of these important ideas, 36 percent stemmed from internal sources, 35 percent from external sources and 29 percent from personal knowledge and experience. It depends on the internal knowledge base and absorptive capacity (Cohen and Levinthal 1990) of the NBD unit whether it can translate these external ideas into suitable new business ideas. Second, corporate venturing is not confined to internal projects. Given the many uncertainties associated with CV, companies increasingly prefer joint ventures and external ventures. Joint
venturing and external venturing both require knowledge on technological developments in the outside world. Based on that knowledge, it can be decided on what topics CV projects can be initiated and with what companies can be collaborated. For example, one of the large venture programs at Shell, concerns the development of hydrogen-based technologies, intended to contribute to the development of an economy and society in which hydrogen is the primary carrier of energy. Shell Hydrogen has a large number of joint ventures. One researcher of OGIR was asked by Shell Hydrogen to monitor the outside world for relevant technologies. This type of research work, which is practiced more and more, is interpreted by the researchers as ‘watching television’.

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.

The monitoring of internal and external developments should be guided by a company’s strategy. Radical innovations that are too far remote from current competences and current markets are likely to fail. Above we indicated that such innovations are located in what was labeled the ‘suicide area’. Nevertheless, CV activities should not merely reinforce existing strategic choices. Strategy, technology and competences should co-evolve.

4.3. Integrating

Corporate venturing based on radical innovation exploits existing competencies in the company but needs at the same time to explore and build new, required competencies in order to successfully set up new businesses. The building of new competencies thrives on the integration of knowledge. According to Grant (1996a: 375) the primary role of firms is knowledge integration. Firms are much better equipped for this integration of knowledge than markets are. Grant bases his theory on Demsetz’s (1991) observation that the acquisition of knowledge requires that individuals specialize in specific areas of knowledge, while the application of knowledge to produce goods and services requires the bringing together of many areas of specialized knowledge (Grant 1996a: 376). No individual is capable of learning everything that is necessary to develop and produce complex products. Individuals have restricted learning capacities. Their information processing capacities are limited (Simon 1991). But whereas the acquisition of an adequate knowledge level requires individual specialization, many production and development processes 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. Grant claims that the capabilities of organizations, their competencies, arise out of the integration of specialized knowledge of individuals. Thus, in order to build new competencies, knowledge created by experimentation and identified by monitoring should be integrated with existing knowledge and competencies. This does not necessarily mean that all knowledge should be collected at one place, in one group or one person. It is often more sensible to integrate knowledge held by specialized individuals or groups by letting these units interact in such a way that each of them applies his relevant knowledge in a concerted way.
As joint and external venturing are becoming more and more important, knowledge management in CV is strongly related to inter-organizational knowledge building and transfer. In addition to learning about alliances and learning in alliances, firms should also learn from alliances (Inkpen and Dinur 1998: 455). External knowledge should be integrated with internal knowledge and the success of spin-in activities depends on the post-acquisition integration skills of the acquiring company (Thomson and McNamara, 2001). Inkpen and Dinur (1998) emphasize that learning from alliances requires rich personal interaction between members of the parent organization and members of the joint venture. The same holds for the integration of knowledge after the spin-in of an external venture. Of course, it is not necessary for everybody to learn what everybody else knows. If that would be possible at all, it would be highly inefficient (Grant 1996b). 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 others contributions. As Grant and others note, mutual understanding and appreciation depend upon the existence of a common knowledge base, a common language. This common ground is often highly tacit in nature. Personal interaction enables the building of such a common ground.

5. 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 and we have analyzed in this paper why these ‘outliers’ behave differently and what the knowledge management challenges are related to learn from distant technological fields to build new competencies and rejuvenate their business portfolio.

Most companies that successfully manage to turn radical technological innovations into new businesses are experienced in corporate venturing (CV) (and new business development). They are organized to incorporate CV as an integral part of their corporate growth strategy. In some examples of industrial companies a dedicated and (semi-)autonomous new business development unit has the specific task to nurture and develop new and profitable businesses based on radical innovations that have been developed internally or acquired from outside including VCFs and start-ups. CV is not only intrinsically related to the corporate strategy but it is also at the core of the renewal process and new competence building activities in the company.

CV is a complex process and the knowledge management challenges are considerable. These challenges are frequently misunderstood because the organization of a CV-unit breaks away in many ways from the organizational requirements of traditional business unit. Similarly, management has a hard time to fully grasp the differences concerning the knowledge management challenges related to radical versus incremental innovations.

CV activities also require a different approach to knowledge management that is predominantly advocated in the literature. Whereas the mainstream of the knowledge management literature focuses on codifying, collecting and distributing knowledge, knowledge management can enhance CV by focusing on experimenting, monitoring and integrating. Knowledge management should not be interpreted as one set of activities that is suitable to all situations. It requires a contingency approach, tailoring initiatives to the typical situations and knowledge characteristics of radical innovations.
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