Radical innovation through internal corporate venturing: Degussa's commercialization of nanomaterials

Elicia Maine

Segal Graduate School of Business, Simon Fraser University, 500 Granville Street, Vancouver, BC, Canada V6C 1W6. emaine@sfu.ca

Internal corporate venturing enables radical innovation within established firms in mature markets. Without effectively designed and managed internal corporate ventures, the organizational constraints of established firms will strongly favour incremental innovation over radical innovation. This paper investigates the evolution of a successful internal corporate venture within a large, incumbent chemical firm, now known as Evonik Degussa, to reveal the challenges, organizational design, and management strategies of their commercialization of radical nanomaterials technology. The commercialization of nanomaterials technology is of great interest to incumbent materials and chemical firms and to independent ventures, but the radical, generic, and capital intensive nature of nanomaterials technology requires organizational and managerial innovation. This case study demonstrates a model to enable growth through radical innovation in nanomaterials, while taking advantage of an incumbent firm's capabilities and complementary assets. Organizational strategies include incubation from a risk-adverse culture, relatively long timelines for evaluation, and a high-level steering committee. Managerial strategies focus on product development, risk reduction, and active risk management.

1. Introduction

Corporate venturing, the term applied to all investments by an existing firm into a new venture, is used by established firms to stimulate growth and to increase exposure to the potential opportunities generated by radical innovations (Zahra, 1991; Block and MacMillan, 1993; Covin and Miles, 2007). Corporate venturing allows insulation from the organizational constraints within established firms in mature markets, which strongly favour incremental innovation over radical innovation. Established firms tend to allocate internal research and development (R&D) resources in a risk-averse fashion, avoiding innovations that overturn their technology or production capabilities. For technology firms in mature markets, the predominant objective for corporate venturing is to overcome this known limitation, in order to pursue the strategic renewal and growth of the firm (Miles and Covin, 2002; Chesbrough, 2003).

Corporate venturing can occur within or outside of the firm, and is referred to as internal or external corporate venturing accordingly (Rind, 1981; Miles and Covin, 2002). Internal corporate venturing carries the highest risks as well as the greatest potential rewards. Although there is a substantial literature on corporate venturing, there is little research elucidating 'contextual factors which encourage or discourage the use

of particular venturing options' (Miles and Covin, 2002), and 'how corporate ventures can gain more freedom to act' (Shrader and Simon, 1997).

Consequently, to advance our knowledge of corporate venturing practices, this paper investigates the evolution of a successful internal nanomaterials venture within a large, incumbent chemical firm to demonstrate the challenges, organizational design and strategies, and management strategies of their commercialization of radical nanomaterials technology. The venturing option used is strongly influenced by the nature of the technology: thus, nanomaterials commercialization is explored as a contextual factor. The structure of this paper is as follows: first, the corporate venturing, radical innovation, contingency theory, and nanomaterials commercialization literatures are briefly reviewed, followed by an overview of nanomaterials activity by established firms. Next, a detailed case study of the innovation environment of Degussa AG, and the genesis and evolution of their internal nanomaterials venture, AdNano, is presented. This case study is then analysed and conclusions are presented.

2. Literature review

2.1. Corporate venturing as a means of pursuing radical innovation

Corporate venturing overcomes the well-known disincentives for radical innovation within the organizational structure of established firms (Sykes and Block, 1989; Leonard, 1995; Christensen, 1997; Hauser, 1998; Leifer et al., 2000). It exposes an established firm to new growth opportunities through investment in external and/or internal ventures. When this investment is in external ventures, incumbent firm goals include assessing and learning from radical technologies and emerging fields (Miles and Covin, 2002; Ernst et al., 2005; Schildt et al., 2005; Weber and Weber, 2007), increasing the innovative output of internal R&D, (King et al, 2003; Dushnitsky and Lenox, 2005) and increasing incumbent profitability (Zahra, 1991, 1996; Zahra and Covin, 1995). External corporate venturing can be direct investment by an incumbent firm into a venture, or indirect investment as part of an externally managed corporate venture capital organization (Miles and Covin, 2002). External corporate venturing is an appropriate method to access potential for growth from radical innovation without a very high commitment from the incumbent firm.

A higher risk, but potentially higher reward, strategy for an incumbent firm to exploit radical innovation is to develop a venture which is wholly owned by the parent firm, but which has separate goals, organizational processes, and corporate culture. The dominant motivations for internal corporate venturing are stimulating growth when the incumbent's core business has reached maturity and meeting corporate strategic goals which cannot be met within the broader organization (Block and MacMillan, 1993). Internal corporate ventures have been used by incumbent firms to explore radical technological innovation, with examples including 3M, Raychem, DuPont, GE, and Hewlett Packard (Hounshell and Smith, 1988; Block and MacMillan, 1993). Internal corporate ventures are wholly owned by the incumbent firm so that they can leverage existing resources and capabilities, enjoy all of the potential upside – including growth, increased profitability, and organizational learning – and have the option of eventually integrating the venture fully within their organization (Block and MacMillan, 1993).

As internal corporate ventures are of both higher risk and higher potential reward than external corporate ventures, managing risk, including restructuring or abandoning an internal corporate venture that is not meeting its strategic goals, is of key importance (Block and Subbanarasimha, 1989; Block and MacMillan, 1993; Leifer et al., 2000). Active medium-term management of risk has been found to increase the success of a firm's venturing activity; however, micromanagement, political constraints, short assessment periods, and a risk adverse culture are detrimental to internal corporate ventures (Burgelman and Sayles, 1986; Block and Macmillan, 1993; Shrader and Simon, 1997). Whereas lower technical and market product risk have been found to increase the chances of success of a corporate venture (Sykes, 1986), radical innovation is inherently high risk. Consequently, evaluation by a credible and influential steering committee, which understands the timelines and inherent uncertainties of radical innovation is recommended (Leifer et al., 2000).

2.2. Contingency factors: radical, generic, and capital intensive nature of nanomaterials

Contingency theory asserts that a firm's contingency should significantly influence how the firm

designs and manages its processes (Burns and Stalker, 1961; Perrow, 1967; Scott, 1981). Firms that design their processes to achieve a fit between the relevant contextual, structural, and strategic factors will yield better performance than firms that do not. Therefore, following studies on project management (Shenhar, 2001), new product development (McCarthy et al., 2006) and the growth of new technology-based firms (Hicks and Hegde, 2005), this paper considers the contextual factors impacting corporate venturing practices. The case study presented and analysed considers the influence of the radical, generic, and capital intensive nature of the commercialization of nanomaterials technology on the corporate venturing practices of a large established firm.

Radical technologies are those which have 'the potential for delivering dramatically better product performance or lower production costs, or both' (Utterback, 1994). Generic technologies are those which may 'yield benefits for a wide range of sectors of the economy and/or society' (Keenan, 2003). Nanomaterials technologies are often both radical and generic in that they are product and process improvements that significantly enhance the cost-performance frontier of functional materials, and have the potential to lead to substantial innovation across several industries (Maine and Garnsey, 2006). Countering this exciting potential, they involve high risk and uncertainty[1] and require specialized capabilities and sustained capital investment over long periods of time to be successfully developed and commercialized (Maine and Garnsey, 2004). High levels of technological risk are influenced by the radical nature of the technology, the number of markets the firm targets, and the need for process innovation. High levels of market risk are influenced by the value chain position of the firm, the number of markets the firm targets, the need for complementary innovation, and the continuity, observability, and trialability of nanomaterials technology (Maine and Garnsey, 2006).

It is unclear whether opportunities presented by nanomaterials technology will be realized by large incumbent firms or by new ventures. Currently, large established firms in the chemical, advanced materials, micro-electronics and pharmaceutical sectors are committing the majority of the corporate research dollars to the development of nanomaterials technology, but 'much of the cutting edge work in nanomaterials is being done by small companies' (Graff, 2003). Although the incumbent firms have far more resources and complementary assets than the start-up firms, large firms also tend to screen their in-house new product development according to current customers and current technological and production capabilities (Christensen, 1997; Kirschbaum, 2005); and the culture appropriate to efficient resource allocation and new product development in the business units of large firms also stifles the culture of experimentation required for the inherently higher risks of radical innovation (Sykes and Block, 1989; Block and MacMillan, 1993; Leonard, 1995). This paper seeks to explore organizational design and managerial strategies which could enable established firms to exploit nanomaterials technology more effectively.

2.3. *Nanomaterials commercialization activity by incumbent materials/chemical firms*

The commercialization of nanomaterials technology is forecast to achieve world market revenues of $90 billion by 2020 (Ondrey, 2005). Nanomaterials technology has the potential to improve products throughout broad sectors of the economy and to enable entirely new markets (National Science and Technology Council, 2003). Large incumbent firms with related technological capabilities are committing most of the private research dollars towards commercialization activity in nanomaterials. Notable examples include Degussa, DSM, BASF, DuPont, GE, Dow and Mitsubishi. Such firms have substantial nanomaterials R&D programmes and are building on their prior capabilities in advanced materials, physics, chemistry, and, in some instances, biotechnology. However, most established firms with capabilities in these areas have focused their new product development resources on incremental innovations and on existing markets rather than on radical or revolutionary innovations or emerging markets because of their previously discussed disincentives for radical innovation.

As examples of the strategic constraints of incumbents, Degussa screens internal technology investments according to the current and future needs of their customers and subject to a time horizon of between 3 and 10 years.[2] GE selects its R&D projects based on their projection of their current customers' future needs (Thayer, 2003). And all of DSM's internal R&D projects are screened to closely complement DSM's existing capabilities, while their external equity investments

do not have to meet these constraints (Thayer, 2003; Kirschbaum, 2005).

Some large incumbent firms have recognized these limitations and have addressed the potential of substantial revenue growth from nanomaterials in two ways. First, they have established an external corporate venturing unit, which monitors, partners with, and invests in new ventures. An example is DSM's Venturing and Business Development group. This group invests in venture capital funds and directly into start-up firms, screening for 'opportunities based primarily on the criterion of whether DSM can use, add and share its core competencies to create value' (Kirschbaum, 2005). Robert Kirschbaum, VP of Innovation, describes the difference between DSM's internal R&D projects and external equity investments: 'What differs is the ratio of risk-to-reward managed as a function of the fit with DSM's core competencies' (Thayer, 2003). DSM's investments in external start-ups are generally 5–30% equity investments, while indirect investment through venture funds result in 2–3% equity investments in start-up ventures. These external investments help to compensate for the strategic constraints and limited growth potential of an incumbents' internal R&D, but capture only a small portion of the potential value from the exploitation of nanomaterials technology.

Second, some large incumbent firms have turned to internal corporate venturing as a method to capture more value from nanomaterials technology by developing them in-house while insulating these R&D efforts from the risk-adverse culture of a large firm in a mature industry. Those that are successful at creating and nurturing internal nanomaterials ventures have the added advantage of direct access to complementary assets and customer relationships from their parent firm. For example, Degussa has developed an internal nanomaterials venture, AdNano, which is conducting R&D, new product development and business development that could not have occurred within the routines and incentive structure of Degussa's established business units. The evolution of this internal nanomaterials venture is described in Section 3.2 of this paper.

3. Case study[3]

This section begins with a brief history of a large chemical and advanced materials firm, Degussa AG,[4] and an overview of their nanomaterials commercialization activity. Next, the development and structure of Creavis, which houses both internal and external corporate venturing activities, is described. Following this overview, a detailed case study exemplar of the genesis and evolution of Degussa's internal nanomaterials venture, AdNano, is examined.

3.1. Degussa AG's nanomaterials commercialization activity

Degussa AG has grown through innovation and amalgamation of similar or complementary firms to form one of the largest chemical companies in the world. Founded in 1873, Degussa began as a joint stock company founded in Frankfurt am Main to mint German currency. By 1880, Degussa began developing capabilities in ceramics. The next few decades brought further growth, investment and new technologies, and expansion throughout Germany, the rest of Europe and to the United States. The founding of new international marketing companies in the 1960s, and several key mergers and acquisitions from the 1970s through to 2001, led to Degussa AG becoming one of the leading suppliers of specialty chemicals worldwide. Degussa is based in Dusseldorf, Germany, with 11 Billion Euros in revenues and 45,000 employees worldwide.

Degussa AG conducts in-house nanomaterials R&D and has a long tradition of technology and production competencies in nanoparticles such as catalysts, pigments, and fumed oxides. However, R&D performed within their regular business units is generally near term, and R&D performed within their corporate R&D unit has been traditionally constrained by their existing core competencies. Thus, they have pursued two avenues to increase their exposure to the growth potential of more radical nanomaterials advances. First, they formed an internal nanomaterials venture within their corporate R&D and innovation unit. Second, they participate in external monitoring of nanomaterials developments and importation of nanomaterials ideas through their Business Ventures group.

In 1998, Degussa reorganized its strategic R&D and much of its new product development into Creavis Technologies and Innovation (known as Creavis), a wholly owned subsidiary with long-term R&D funding from the Degussa Corporate Center and short-term R&D funding from Degussa business units (Challener, 2003). Creavis focuses predominantly on the development of

new technology platforms and the exploitation of existing technologies in new markets. Although production competencies in more mature nanomaterial technologies exist in three Degussa business units, most strategic nanomaterials R&D at Degussa takes place within Creavis. Long-term and relatively high risk research within Creavis is funded by Degussa Corporate, while closer to market R&D receives additional funding from one or more of Degussa's 17 business units. Each Degussa business unit must put 10% of their R&D budget into Creavis. A steering committee, which includes the Chief Operating Officers responsible for the business units, guides Creavis' major decisions.

The overall structure of Creavis, which includes the Business Ventures group, the Exploration and Validation group, Internal Ventures, and a Science to Business Unit, is depicted in Figure 1. The functions of these groups 'range from the investigation of promising new technologies and likely market requirements by Business Ventures to the laboratory implementation of promising ideas by Exploration and Validation, and include the introduction of newly developed products and technologies into markets by Internal Ventures'.[5] Two broad categories of projects exist within Creavis: that where the technology is outside of Degussa's existing competencies and not fitting within Degussa's current portfolio, and that where the technology is complementary to existing competencies or fitting with the current portfolio but the risk is too high for the business units by themselves. The former are housed within the Business Ventures group, whereas the latter are channelled into project houses and internal ventures. Project ideas of both categories are first vetted within the Exploration & Validation group. Exploration & validation teams work actively with universities, research institutes, suppliers and customers from the very early stages of project development to evaluate the viability of future markets and technologies and to perform the laboratory R&D to assess technical feasibility.

The externally focused Business Ventures group mandate is to identify emerging technologies with a high potential to add value and new business for Degussa, within a 3–10-year period.[6] The Business Ventures group monitors external technology, market, and competitive developments and may license or purchase intellectual property, engage in strategic collaborations, establish equity investments or acquire a technology or company. Their partnership, investment and acquisition choices are guided by their aims of providing future growth opportunities for Degussa, increasing Degussa's technological strengths, increasing the speed of development in commercial and competitive technological projects, and reducing market risk through collaboration with customers and alliance partners. None of Degussa's current investments are in nanomaterials ventures, with the exception of their internally developed and wholly owned

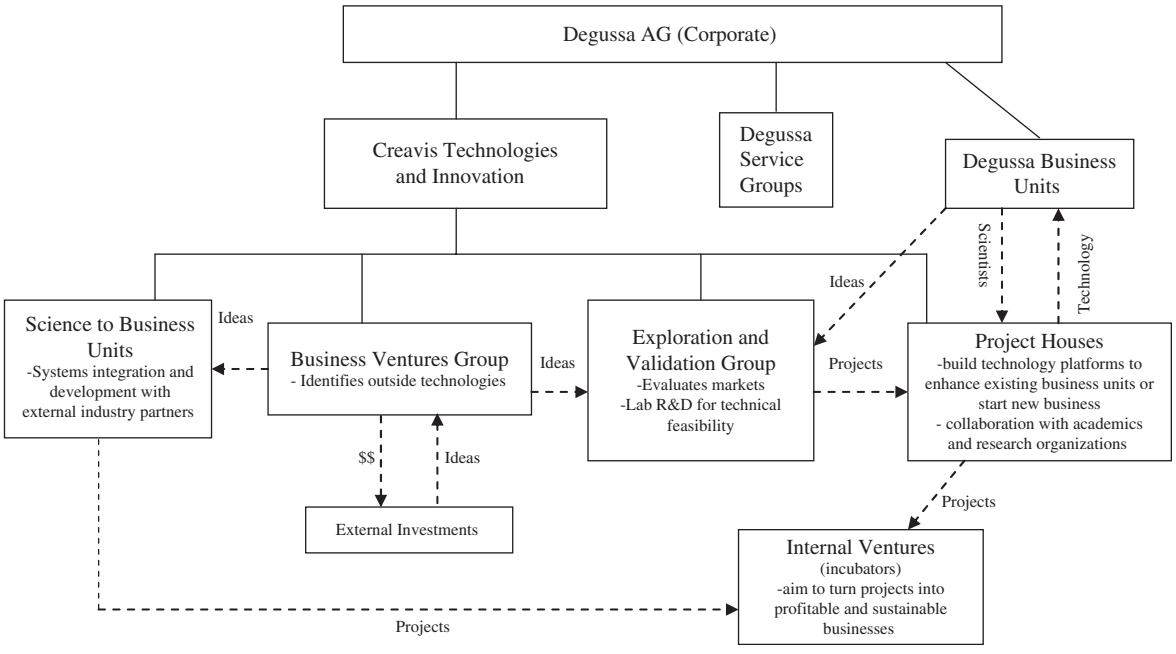

Figure 1. Organizational Structure and Functions of Degussa's Innovation Unit., Creavis.

nanomaterials venture, AdNano, which is described in Section 3.2.

Degussa does have external nanomaterials partnerships through their first 'science to business' unit, Nanotronics. Science to business teams are differentiated from project houses in that the original ideas originate externally and external collaborators participate in R&D. New product development projects from successful science to business teams may still become internal ventures and may eventually create a new Degussa business unit or be integrated into an existing Degussa business unit.

By closely monitoring emerging technologies and markets, Degussa positions itself to take advantage of future potential growth markets enabled by nanomaterials. However, internal R&D is also required both to recognize these opportunities and to facilitate alliance creation. Markus Pridöhl, senior manager for R&D at Degussa Advanced Nanomaterials stresses that complementary intellectual property positions are a key factor for establishing and maintaining strategic alliances (Ainsworth, 2004). Thus, internal nanomaterials R&D is vital to creating and maintaining growth options from the exploitation of radical nanomaterials technology developments.

The internally focused project houses are created from platform technology opportunities categorized as 'medium risk' and complementary to Degussa's capabilities. These project houses are staffed by employees from multiple Degussa business units and from within Creavis. Each project house is given a window of 3 years in which to 'start a new business start-up and/or enhance the existing capabilities of its business units, whether it is through new products or through access to new markets'.[7] AdNano was Degussa's and Creavis' first project house, and its success led to the creation of five additional project houses, each staffed by 20–30 scientists.[8]

Successful project house projects, which are still too risky or too long term for a business unit become internal ventures. Internal ventures 'incubate[s] the business from inception as a start-up to sales and profitability of a mid-sized business, after which the business is typically transferred to a Degussa business unit'.[9] After breaking a new path as Degussa's first project house, AdNano also became Degussa's first internal venture. Since then four other internal ventures have been created within Degussa. AdNano serves as a case study exemplar of an incumbent's internal nanomaterials venture. AdNano won an external award for leadership in nanomaterials commercialization and has successfully developed several new products and processes which were incorporated into Degussa's Aerosils and Silanes business unit in 2007.

3.2. Degussa Advanced Nanomaterials (AdNano)

Degussa's internal nanomaterials venture, AdNano, was conceived in 1998 as an idea from a group of five people working on gas-phase processing of ultra fine particles within Degussa's Central Process Technology Group. The Central Process Technology Group is a corporate services unit, which serves all of Degussa. In this instance, the team, led by Dr. Andreas Gutsch, was collaborating with two of Degussa's business units: Advanced Fillers & Pigments and Aerosil & Silanes.

Gutsch's research group began looking for funding to work on their ideas, which were too high risk for the business units to be interested in funding directly. However, Germany has a government funding programme called Deutsche Forschungsgemeinschaft, similar to the United States' National Science Foundation, which was funding innovative nanomaterials R&D. Gutsch, along with Geoffrey Varga (at that time an internal consultant from Degussa's Electronic Materials subsidiary in New Jersey) proposed that Degussa create a 'project house'[10] for risky but high-potential nanomaterials R&D within Degussa, which would be subsidized by the German government. They applied for and were successful in obtaining government funding, conditional on matching funding from a corporate sponsor. Degussa corporate agreed to match most of the funding, with a smaller portion contributed through additional funding from both relevant business units. The funding coincided with the inception of Creavis, and the team implemented the formation of Degussa's first project house (Figure 1).

In 2000, Degussa Project House Nanomaterials (PH Nanomaterials), wholly owned by Degussa AG, began with €13 million in total funding. This consisted of €6 million from Deutsche Forschungsgemeinschaft, €4 million from Degussa corporate, €1 million each from the two relevant Degussa business units, and €1 million from the German Ministry for Education and Research. Degussa and Creavis management decided from the start to limit the lifetime of Project Houses to

3 years. Given their overall funding, Gutsch, as the first leader of PH Nanomaterials, compiled a team of 17 technician and professional staff from various parts of Degussa, which included the original Central Process Technology Group team, Varga, who relocated to Germany full time in 1999 to help initiate PH Nanomaterials, and staff from Degussa's Advanced Fillers & Pigments and Aerosil & Silanes business units. Gutsch, who had previous experience managing a strategic development group at Degussa, designed PH Nanomaterials to consist of an interdisciplinary team of researchers with marketing input right from the beginning. He intentionally brought together employees with experience in materials science, chemistry, physics, industrial design, production, and marketing, and had them work in close proximity within one building. Beyond the physical proximity of diverse R&D and functional specialists, Gutsch also established routines and incentives to encourage free communication.

PH Nanomaterials was considered an experiment of how to innovate in a large firm. So, although it was only a 17-person project within a firm of over 50,000 employees, it reported to a steering committee which closely followed its progress. For the first 12–18 months, they were in experimental mode and did not have a lot of market focus. Between 12 and 18 months they became more focused on market applications. PH Nanomaterials enjoyed some early technical successes in areas which were also seen to be highly relevant to Degussa's customers. During its 3-year life-span, PH Nanomaterials developed promising new nano-structured materials offering distinctive functionalities.

Around the 18-month mark, Gutsch and Varga realized that PH Nanomaterials had internal support and some momentum but would soon be facing the notorious 'Valley of Death'. Varga had experience with technology start-up firms in the United States, and knew some of the challenges they were likely to face. He also knew that their product development team would face potentially insurmountable management and incentive problems if they moved directly into an established Degussa business unit before they incubated the technology independently. Varga was further convinced that an alternative organizational structure was required though reading *Corporate Venturing* (Block and MacMillan, 1993), which warned of the dangers of subjecting a new venture team to the management routines and incentive systems of a large firm too soon. Gutsch and Varga pitched their ideas to the steering committee of Creavis, and, after proposing that their alternative was to spin out the venture externally, won management agreement to start the internal corporate venture AdNano. In early 2002, after securing agreement to begin Degussa's first internal corporate venture in a year's time, Gutsch was promoted to the head of Creavis, and Varga was promoted to the head of PH Nanomaterials and the director of AdNano.

Gutsch and Varga had secured an agreement that AdNano would have 4 years of 'political protection' as an internal venture during which time it would incubate the new technology and product processes and start the integration process into one or more of Degussa's existing business units. Degussa corporate, Creavis, and the Aerosil & Silanes business unit agreed to contribute 25 million Euros to the internal venture. After 4 years time, if successful, they would become completely integrated within Degussa's Aerosil & Silanes business unit (Figure 2). Although Varga had proposed the idea of spinning the venture out externally in order to convince Degussa management to agree to the internal venture, he was always convinced that the resources and capabilities of Degussa's Aerosil & Silanes business unit would be an immense help to AdNano in their development. This proved to be the case, with AdNano drawing extensively on the marketing and production expertise of the Aerosil & Silanes business unit.

Degussa's first internal corporate venture, AdNano, was formed in 2003. As with PH Nanomaterials, it remained wholly owned by Degussa AG. Most of the personnel from PH Nanomaterials continued with AdNano and 50% more staff were brought into the venture. All employees continued to be on Degussa's payroll, but were given the option to exchange their standard Degussa bonus incentives for AdNano sales and earning incentives. Thus, AdNano employees had financial and career incentives to help make AdNano a success, without the personal risks associated with an independent venture.

AdNano's stated goal was 'to produce innovative nanomaterials and tap into new business segments in attractive markets'.[11] Their steering committee put in place both financial and non-financial milestones to determine success or failure. The financial milestones were in the areas of target sales, profit, and capital expenditures. The non-financial milestones were in the areas of resource building, internal execution, customer

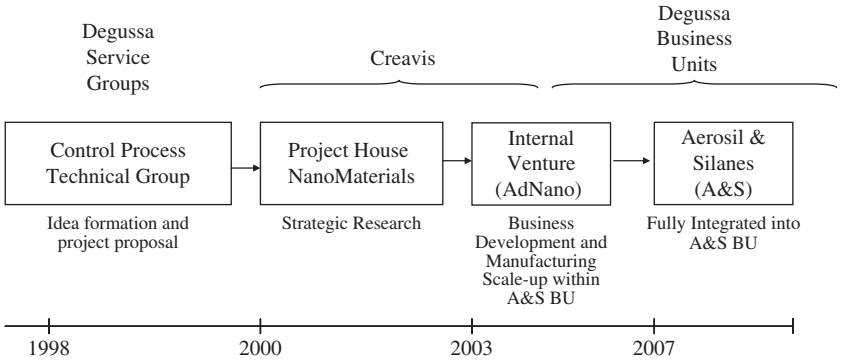

Figure 2. Evolution of Internal Venture Degussa Advanced Nanomaterials (AdNano).

acceptance of technical performance, and external perception. The steering committee made it clear that AdNano would be abandoned if the significant milestones were not achieved.

AdNano met this goal by developing nanostructured materials and dispersion systems including indium tin oxide, zinc oxide, ceria, and various composites. AdNano's biggest successes were in the area of fumed oxides, making them a much more natural fit with the Aerosil & Silanes business unit than the Advanced Fillers & Pigments business unit. AdNano's steering committee determined that AdNano had met enough milestones by the time that their 4-year window of incubation expired in 2007 to be fully integrated into Degussa's Aerosil & Silanes business unit (Figure 2). AdNano and now the Aerosil & Silanes business unit have been customizing these products for key customers in the automotive, consumer electronics, chemical, energy, and cosmetics industries. AdNano focused on product and process development work, which can be considered variations of standard Degussa technology. AdNano developed a diversified portfolio of product applications, about 80% of which had some existing market pull. The other 20% of their efforts were focused on creating new markets.

AdNano encountered political resistance when they began developing products with the potential to cannibalize portions of existing product lines within the Aerosil & Silanes business unit. However, with the support of their high-level steering committee, they were able to overcome this natural organizational resistance. AdNano's Director, Geoffrey Varga, explained:

> Two of our leading 4 materials in fact have the potential to partially substitute existing offerings in the market from the Aerosil & Silanes business unit. These two materials both have multiple applications, and several of those have some overlap with established products. Of course business unit product line management initially had some concerns about this, but with support from upper management we were able to move forward. Eventually it became clear to everyone involved that developing replacements or alternatives for your existing offerings in the market for both present and potential future applications is preferable to waiting for your competitors to do it first. These are the kinds of issues where the support of very high-level management can help to keep things on track and guide activities in the proper direction, providing much needed political protection at critical points in time.[12]

Thus, AdNano was able to avoid one of the common constraints encountered by internal corporate ventures.

AdNano heavily leveraged Degussa's expertise and established production and marketing and sales competencies. AdNano had their own pilot production and used it to 'sample potential customers with materials, conduct β-testing, as well as providing multi-ton quantities for proof-of-concept in the market while the production facilities are being designed & built'.[13] Given the economies of scale required to profitably manufacture and sell these products, AdNano did not generate substantial product revenues before integrating into the Aerosil & Silanes business unit of Degussa. Varga was wary of attempting to rapidly integrate into the Aerosil & Silanes business unit at the end of AdNano's incubation time, and decided instead to smooth this process over the year before full integration, gradually transferring people and ideas into the Aerosil & Silanes business unit. AdNano also worked closely with the Aerosil & Silanes' design and production engineering group

to develop their own higher volume manufacturing facilities.

4. Analysis

Degussa's AdNano demonstrates a viable model for the development and commercialization of radical nanomaterials technology. Their organizational design as a protected internal corporate venture with relatively long timelines and a high-level steering committee, and their managerial strategies regarding product development, risk reduction, and active risk management were key to their success. In this section, the context of the challenges faced by Degussa in creating value from radical nanomaterials technology are analysed. Next, the organizational and managerial strategies employed are analysed. Finally, the advantages and disadvantages of AdNano as an internal corporate venture as compared with an external corporate venture are discussed.

Degussa AG, like other incumbent firms in mature markets, experienced organizational constraints to radical innovation. Consistent with the literature, their organizational culture, which enabled efficient resource allocation, limited opportunities for growth through radical innovation. This led to their 1998 reorganization of higher risk and less aligned research and innovation into Creavis (Figure 1), and the instigation first of project houses and then of internal corporate ventures to incubate higher risk R&D and product development from the incentives, resource allocation processes, short assessment periods and risk adverse culture of the rest of the firm. PH Nanomaterials, as the first organizational experiment with the incubation strategy of Creavis, was initially given 3 year's incubation as a project house. Following promising technical development and discussion of context appropriate timelines, their incubation period was extended for a further 4 years as a more commercially focussed interval venture. AdNano created sufficient value to be considered a successful organizational experiment (Table 1). Five subsequent project house projects and four internal corporate ventures were created within Creavis during AdNano's incubation period.

AdNano created substantial value by achieving its technical goals and by developing and β-testing significant new business opportunities which are being exploited though an existing Degussa business unit. These new opportunities include four new materials, engineered at the nanoscale, which can be applied to multiple applications in the automotive, consumer electronics, chemical, energy, and cosmetics industries. The longer assessment periods and shelter from the political constraints and risk-adverse culture of the business units were highly important for AdNano's success. In fact, the milestone timelines were likely too optimistic for the reality of the required commercialization process as 'the commercialisation of [these nanomaterials] proved to be a long process due to many factors such as customer qualification and delays related to the interdependence risks along the entire value chain'.[14]

AdNano employed several managerial strategies to overcome some of the challenges to nanomaterials commercialization in their environment (Table 1). Their managerial strategies to stimulate and guide product development began at PH Nanomaterials, where Gutsch assembled an interdisciplinary development team with experience in materials science, chemistry, physics industrial design, production, and marketing. Gutsch aligned his teams' incentives with the success of AdNano, and established a corporate culture encouraging exploration and communication. As PH Nanomaterials became AdNano, the decision to focus 80% of their efforts on existing markets reduced the risks of failure while also taking advantage of the complementary assets of their parent company. Maintaining some exploration of emerging markets allowed AdNano to build the IP and market awareness for future growth opportunities. Lastly, their persistence in and high-level support for developing new products that may cannibalize portions of Degussa's existing product lines mitigated a major drawback of internal corporate ventures.

AdNano's managerial strategies to reduce risk were particularly important given the high levels of risk and uncertainty inherent in nanomaterials innovation. AdNano's technological risk stemmed from the radical nature of their technology, needing to meet technological requirements of five different markets, and their need for process innovations. Their market risk stemmed from the upstream position of AdNano in the value chains of their five target markets, their need for complementary innovations in order to commercialize their technology, and the lack of continuity, observability, and trialabilty of their technology by their customers without extensive product development and design work (Table 1). AdNano's strategy to reduce these risks included β-testing of their products with existing Degussa customers, drawing on the production and marketing expertise of Degussa,

Table 1. Analysis of Degussa's internal nanomaterials venture

	Degussa Advanced Nanomaterials (AdNano)
Origination	1998
Founding year	2003 (following 3 years as a research project house)
Technology	Nanoparticle processing
Ownership	Fully owned internal venture of Degussa AG
Technological uncertainty at founding	High (radical technology; established substitute products; need for process innovations; multiple markets)
Market uncertainty at founding	High (upstream position in value chain; need for complementary innovations; lack of continuity, observability, trialability; multiple markets)
Strategic constraints	Allowed some cannibalization of current business unit product offerings, but mainly focussed on enhancing and leveraging existing capabilities of existing business unit
Access to complementary assets	In-house business unit, Degussa Aerosil & Silanes
Availability of finance	€38 million over 7 years from German Government, Degussa Corporate, business units
Value created	Developed four new materials with multiple applications, β-testing of products with customers, initial modest revenues from pilot scale manufacturing of nanomaterials, creation of intellectual property, lowering of technical and market risk such that new product manufacturing was successfully integrated into existing Degussa business unit
Target markets	Automotive, Consumer Electronics, Chemical, Energy, Cosmetics
Organizational design	*Corporate venturing division*, Creavis, formed to incubate higher risk and longer term R&D and new product development projects from organizational pressures of existing business units. *Multidisciplinary project house* team formed with a culture of experimentation and risk tolerance and receives large government subsidy. Limited term *internal corporate venture* with business development milestones and active risk management
Organizational strategies	Incubation, relatively long timelines, high level steering committee
Managerial strategies	*Product development* was enhanced through cross-disciplinary, co-located teams with routines encouraging communication and aligned incentives. Their focus on existing markets took maximum advantage of the complementary assets of relevant business units within Degussa. They were able to develop products, which could cannibalize existing product lines. *Risk reduction* strategies included β-testing of their products with existing Degussa customers, drawing on the production and marketing expertise of Degussa, and focusing their product development on existing markets while still exploring emerging markets. *Active risk management* was practiced by the steering committee with financial and non-financial milestones assessed over timelines appropriate to the industry and the level of risk and reward.

and focusing their product development on existing markets while still exploring emerging markets.

These strategies for risk reduction do not eliminate the need for active risk management techniques. Unless a firm is willing to walk away from an unsuccessful internal corporate venture, they will waste resources that could be used on other ventures. AdNano's steering committee used such strategies, including creating financial milestones in the areas of target sales, profit, and capital expenditures, and non-financial milestones in the areas of resource building, internal execution, customer acceptance of technical performance, and external perception. They also instituted limited timelines to achieve these milestones, and communicated that AdNano would be abandoned if the significant milestones were not achieved. This threat was credible, as another similar Degussa internal venture was abandoned for these reasons. According to Varga, 'Integration & continuation of the efforts within the business unit was due to the fact that the steering committee did see a good potential for success'.[15]

AdNano's main advantages over an external venture were direct access to complementary assets, sufficient financing, and superior upside for Degussa if they were successful. Complementary assets and substantial capital investment are required for value creation by new ventures in the advanced materials sector, but are difficult for external ventures to access (Maine and Garnsey, 2006). AdNano enjoyed direct access within Degussa's Aerosil & Silanes business unit to design and production capabilities, marketing and established customer relationships. Through Degussa, €38 million for 7 years of insulated development was secured. These were significant sources of advantage to AdNano as an internal corporate

venture. An external venture would not have had this degree of access to comparable complementary assets even with strong alliance and investment partners. Degussa would not supply the level of access granted AdNano to an external venture because of IP concerns. Additionally, Degussa would receive greater transfer of knowledge and great financial reward upon AdNano's success relative to a comparable level of success for an external venture.

The main disadvantages for AdNano relative to an external venture were the strategic constraint of developing new complimentary products for an existing business unit and the higher costs of failure to Degussa. Despite the political protection provided by their steering committee, AdNano was still limited in their product development by organizational pressures to leverage and enhance the existing capabilities of the Aerosil & Silanes business unit and by the timelines imposed on them to complete their experimentation within Project House Nanomaterials and their business development within AdNano. Additionally, failure for AdNano would have meant the loss of the sizeable capital and time investments in PH Nanomaterials and AdNano, as well as reputational damage to Degussa. Failure for an external venture would be more costly to the venture itself, and to their employees, but less costly to Degussa.

5. Conclusions

This paper makes two main contributions to the corporate venturing literature. The first contribution is revealing how the radical, generic, and capital intensive nature of nanomaterials innovation influences a firm's venturing options. The second contribution is examining the organizational and managerial strategies used to enable success and reduce constraints on an internal corporate venture pursuing radical, generic, capital-intensive innovation. The case study examined in this paper suggests that incumbent materials and chemicals firms who are able to insulate their nanomaterials R&D through a willingness to consider longer time horizons for evaluation, cannibalization of current product lines, niche or emerging markets and redirection or termination of poorly performing ventures will have the best opportunity to profit from nanomaterials technology.

Nanomaterials have gained the widespread attention of national governments, research organizations, large incumbent firms, venture capitalists and new ventures. As the most developed sub-sector of nanotechnology, nanomaterials commercialization activity is providing initial evidence of the emerging organizational and managerial strategies that could prove successful in the wider exploitation of nanotechnology. With the organizational and managerial strategies described in this paper, incumbent materials and chemical firms are better placed to exploit radical innovation in nanomaterials than independent ventures. Whereas independent ventures are unconstrained in their R&D and are the source of many novel technologies in nanomaterials, internal corporate ventures within incumbent firms have the financial resources, the R&D strength, the production competencies, the marketing competencies, the customer relationships, and the distribution systems to more efficiently exploit radical innovation in nanomaterials. Thus, for established firms with the required complementary assets, internal corporate venturing is more conducive to profiting from nanomaterials than external corporate venturing.

Degussa's success with AdNano and with internal corporate venturing can be attributed to several practices recommended in the literatures on corporate venturing and radical innovation. First, a corporate venturing division, Creavis, was created to incubate higher risk research from the routines and incentives of the broader organization, and to take advantage of government subsidies for high-risk research and development. Second, long timelines and a high-level steering committee were established for evaluation of experimental project houses and of more commercially focussed internal ventures. Managerial strategies in the areas of product development, risk reduction and active risk management were employed. Cross-disciplinary, co-located teams with routines encouraging communication and aligned incentives were established. AdNano was allowed direct access to the complementary assets of relevant business units within Degussa and yet to cannibalize existing product lines. Risk reduction strategies included β-testing of their products with existing Degussa customers, drawing on the production and marketing expertise of Degussa, and focusing their product development on existing markets while still exploring emerging markets. Lastly, active risk management was practiced by the steering committee over timelines appropriate to the industry and the level of risk and reward.

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Notes

1. Although both risks and uncertainties are involved, the rest of this paper will refer mainly to risk, as we are focussing on factors which managers can influence. The uncertainties are managed by redirecting or terminating projects and ventures which are no longer considered promising when formally evaluated.
2. http://www.creavis.com/site_creavis/en/default.cfm?content=bto/mission, accessed on 24 February 2006.
3. This case study was based on primary source interviews with the Director of Degussa Advanced Nanomaterials, Geoffrey Varga, conducted on 21 February 2006, 24 February 2006, and 31 December 2007, and from secondary source information from Degussa's websites www.degussa.com http://www.creavis.com and http://www.advancednanomaterials.com, accessed on 2006 and 2007.
4. Degussa AG was sold in 2006 to RAG. After rebranding in September of 2007, Degussa became the Chemical Business Area of Evonik Industries AG, and is referred to as Evonik Degussa.
5. http://www.creavis.com/site_creavis/en/default.cfm?content=download&cat=14, accessed on 10 February 2006
6. http://www.creavis.com/site_creavis/en/default.cfm?content=bto/mission, accessed on 12 February 2006
7. http://www.creavis.com/site_creavis/en/default.cfm?content=download&cat=14, accessed on 10 February 2006
8. http://www.creavis.com/site_creavis/en/default.cfm?content=bto/mission, accessed on 12 February 2006
9. http://www.creavis.com/site_creavis/en/default.cfm?content=download&cat=14, accessed on 10 February 2006
10. Degussa Starts New Project House. Retrieved from http://www.azom.com/news.asp?newsID=2700 on 21 February 2006.
11. http://www.degussa.com/degussa/en/press/news/details?NewsID=1033, accessed on 12 February 2006
12. Primary source interview with Geoffrey Varga, 24 February, 2006.
13. Primary source interview with Geoffrey Varga, 24 February, 2006.
14. Primary source interview with Geoffrey Varga, 31 December, 2007.
15. Primary source interview with Geoffrey Varga, 31 December, 2007.

Elicia Maine is an Assistant Professor of Technology Management at the Segal Graduate School of Business at Simon Fraser University in Vancouver, Canada. She received her PhD in technology management at Cambridge University and master's degrees in technology and policy and in materials engineering from the Massachusetts Institute of Technology. Her works have appeared in *Research Policy*, *International Journal of Technology Management*, *Technovation*, *Materials and Design*, and *Advanced Engineering Materials*. Her current research focuses on technology entrepreneurship, technology policy, and technology management, with a focus on the commercialization of advanced materials. She teaches innovation and strategy to MBA and undergraduate students.