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The research agenda on innovation processes in firms

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Preface

This report presents the results of work done as “Task 1” of the Work Package 1 (WP1) on “Innovation Processes”. WP 1 is one of four sub-projects in the project “Understanding innovation in a globalizing economy: The Norwegian case” funded by the Research Council of Norway, in their research program “Vekstforsk”.

The rationale for the project “Understanding innovation in a globalizing economy: The Norwegian case” is based on the recognition that as a result of globalization, new ways of organizing production and new modes of innovation have emerged. The traditional ways of closed modes of innovation and intra-mural knowledge bases have increasingly been substituted by more open modes of innovation and distributed knowledge networks. The goal of the project is to analyze this and develop a new conceptual framework relevant for innovation policy in Norway.

Within this framework, the aim of WP1 on “Innovation Processes” is to study knowledge generation and innovation processes in different types of Norwegian firms and industries (dominated among other things by specific knowledge bases), and in different regional settings. In “Task 1” of this, the aim is to describe, analyze and discuss the existing, contemporary research and knowledge base that are relevant for approaching the topic of WP1. The results of this work are presented in this report.

The report has been written by Helge Godø of NIFU STEP, in collaboration with Sverre Herstad and Trude Røsdal, who have also contributed with comments of drafts.

Oslo, March 2009

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1 Introduction – How firms innovate

During the past decades, companies have gradually changed how they organize and implement innovation activities and, more significant, decision making and strategies related to product and process development, R&D. Essentially; this is all about how firms attempt to develop competitive advantages by means of innovation.

The purpose of this paper is to provide an overview over existing, contemporary research literature, in order to evaluate and discuss issues and questions that are relevant for the research agenda on how firms organize their innovation activities – and why. More specifically, this topic will be approached by posing the questions initially asked in the proposal for this project. The main questions posed were:

- How do firms make decisions on innovation activities?
- Who decides, and what are the factors that guide strategies and tactics of innovation activities?
- More specifically, when and why do firms decentralize or centralize R&D and innovation activities?
- What internal resources beyond R&D staff enter as key contributors to these activities?
- What determines their mix and build-up of an innovation portfolio?
- When and why do firms make or break alliances with their competitors in innovation activities?
- What kind of role does private equity and venture capitalists play in firms' innovation strategy and performance?

Needless to say, these questions are broad, so broad that attempting to answer these in a satisfactory or comprehensive way is almost impossible, at least within the framework of this project. Still, the paper will attempt to present the research according to general characteristics of the approaches, such as focus, analytical levels and units, theoretical positions and disciplinary affiliation, types of explanations offered, etc. At the end of this paper, the material presented will be discussed and evaluated in terms of its implications for the current research and analyses. This is particularly relevant now because we are in the process of analyzing the results from the MINE-survey in Norway. In this, response was obtained from 56 industrial firms that are characterized as being innovative. This material, together with analyses of the material from the international MINE survey (almost 1,000 responding firms) will become the main task in the next phase of the project.

The main challenge in doing a review on the topics of this paper is an abundance of research literature. This abundance reflects an increasing interest for innovation in general because innovation has now become widely acknowledged as essential and strategic in a number of areas that are important in society, such as profitability and long-term viability of industry, industrial and regional development, various areas of policy making, level of

welfare of society, international competitiveness, etc. In spite of this abundance, the questions asked above do not have clear answers, which may explain why some innovation research scientists characterize innovation processes within firms as a "black box", suggesting that knowledge and explanations in this area do not provide satisfactory insights. In addition to being abundant, the research literature may be characterized as highly heterogeneous, so much that one may wonder if researchers are focusing on the same phenomenon, i.e. on how firms innovate. In the rest of this introduction, this will be briefly commented because this aspect is relevant for understanding the delineation and focus of this paper.

One large bulk of literature in innovation studies is what may be termed "practical handbooks" in the sense that these have a *prescriptive intent*, i.e. they provide tangible advice on how managers (mostly) and people involved in innovation processes should do their work, e.g. product developers. Although some of these appear to be based on research (or claim that their advice is built on "solid" research, cf. works of the product development guru Robert G. Cooper (1996; 2000)) or insights of people who have profound understanding and experience in work with innovation processes, the main purpose of this literature is give advice, often termed as "best practice". The journal *IEEE Engineering Management* fits into this category because many of the articles are on technical topics related product and process development performance and quality.

A similar, but more interesting type literature in terms of research belongs to a category which may be labelled as having a *normative intent*. This literature is also highly heterogeneous, reflecting that there are many normative positions in this type of research, implying that innovation researchers doing this type of research have political sympathies that at times are explicit in their policy or ideological agendas. One classic topic is related to the role of market dynamics in innovation, i.e. belief in the powers and virtues of market mechanism for society, hence advocacy of policies that promote market mechanisms in innovation (Drucker, 1985; Hope, 2003; von Hippel, 1988; von Zedtwitz & Gassman, 2002). In opposition to these, there are researchers (Dosi, 1988; Lundvall, 1988; Rosenberg, 1994) who suggest more complex and alternative explanations; by this they contest the supremacy of market mechanism in innovation. An earlier and authoritative review of this tension is provided in Mowery and Rosenberg (1982). A different type of innovation studies that have normative orientation put emphasis on promoting key conceptual frameworks from which normative prescriptions are derived. One of these which is currently enjoying some success is the idea of "Open Innovations" (H. Chesbrough, 2003; H. Chesbrough, Vanhaverbeke, & West, 2006). Earlier, the notion of "core" had a similar success, such in the concept of "core competency" (Hamel & Prahalad, 1994) and "core business" (Porter, 1990), although in the latter the role of innovation processes is less pronounced.

A third category of innovation research may be classified as having an *ontological intent* because its main purpose is to understand and explain innovation as a phenomenon,

without necessarily advocating any policy positions or giving advice on how things ought to be done. In fact, Bruno Latour, one of the researchers of this category, has explained that he is "agnostic" in terms of outcomes of innovation activities, i.e. that he does not want to make assessment as to the merits or criticize the outcomes of innovation activities – he just wants to explain what happens when something new is created. Within this group, there is also an abundance of research that is interesting because of the insights that they provide on innovation processes. Some of these will be elaborated in the following pages, such as the conceptual frameworks of:
- technological regimes (Malerba, 2004; Rip & Kemp, 1998)
- innovation journey (Ven, Polley, Garud, & Venkararaman, 1999)
- innovation game (Miller & Floricel, 2007; Tirpak, Miller, Schwartz, & Kashdan, 2006)

Although using these three, broad categories of innovation models, i.e. prescriptive, normative and ontological, may be fertile for understanding different perceptions and interpretations of innovation, these categories will not structure the analyses in this paper. Instead, the focus will be set on how firms make decisions on innovations. This will cover a broad range of issues, starting with the question of why firms (mostly) do innovations as an in-house activity. After this, the focus will be set on decision-making related to innovation activities and various organizational aspects related to this. Then the paper will explore some structural perspectives that influence innovation strategies and decision-making in firms, including what may be termed as "strategy cycles", i.e. oscillation between various types of strategies that firms pursue.

The last part of the paper will look more closely at the conceptual framework of "innovation games", because this is important for understanding the MINE-survey. After this, the paper will conclude with a discussion and analyses of research items and topics that are relevant for elucidating the questions related to how and why firms make decisions on innovation activities. In this conclusion, the paper suggests that the early stages (initial period) of an innovation process seems to be very crucial, yet poorly understood because of its complexity and elusiveness. Although this is recognized by some research and by many practitioners, and reflected in concepts such as "gestation period" (i.e. pregnancy) and "Fuzzy Front-End" of innovation, there is little research that in this area. In this, research seems to ignore important factors such as the role of serendipity and aesthetics – and the notion of *homo ludens* which often appears to be important when innovation processes are initiated and for this reason sets the course and direction of the innovation process. This should be a topic for further research, however, before this may be done, we need to have a better understanding of more prosaic aspects and factors related to innovation processes.

2 What is the problem?

In a seminal paper from 1988, David Teece (1988) asks why firms – in spite of what economists believe is rational – resist or are hesitant in terms of outsourcing technological development, i.e. why firms persist at keeping these types of activities and others related to innovation in-house. Furthermore, he asks why are "make or buy"-decisions related to technological development so difficult? And why are these issues considered as crucial to the firms' strategies? Following this, why do firms tend to specialize and "stick to" certain fields and technologies? One reason he asks these questions is that "...standard microeconomic analysis would indicate that contracting for R&D-services from an established low-cost provider will be the superior alternative, just as it would be for any other service or component" (Teece, 1988, p. 259). In analyzing this, Teece argues that there are no type of contracts or contractual relationships that are able to govern innovation activities in a way that serves the requirements of these types of activities. He gives numerous examples from firms that have attempted and abandoned this because their experience with outsourcing technological development and innovation activities showed that this did not provide the cost reductions or quality improvements that they expected. Secondly, Teece suggests that "..profit-seeking firms have limited abilities to change products and technologies" (1988, p. 266), indicating that most firms are governed by a technological lock-in and associated path-dependencies. These considerations – that most firms seem to think that doing innovation activities in-house makes good sense and that they tend to specialize in certain technological areas – do not contradict that they simultaneously may enter into collaborative relationships with outsiders, even competitors, on various innovation projects. A common type of external collaboration is with public institutions such as universities and public research institutes in joint R&D projects. Still, innovation, or R&D as Teece calls this, has to be an activity dominated and controlled by the firm itself.

The views that Teece expounded in this 1988 paper were significant because it was published in at period when the Zeitgeist advocated a radical downsizing of R&D in firms, as typical of what Roussel, Saad and Kash (1991) call the "2nd generation R&D". To illustrate, in this period some top managers who advocated this type of policy, would state in interviews that if they should for some reason need R&D and product development work to be done, they would just pick up the phone and order this from an outside vendor, just like ordering a pizza: Why should they bother to keep and staff a pizza bakery in-house to serve this need? In spite of these sentiments, statistics indicate that the level of private sector R&D and other types of innovation activities has remained stable, some figures indicate a slow growth mode in a long term perspective (S. Herstad, 2008, pp. 38-39) over the past decades. Although some sectors have undergone restructuring in terms of the division of labour related to R&D and innovation, this is still predominantly done inside firms as an in-house activity. This is seen in traditionally R&D-intensive sectors such as telecommunications, electronics and computers where large telecommunications operating

companies such as AT&T and British Telecom has reduced its in-house R&D significantly, while equipment manufacturers have absorbed this reduction and the sector itself has increased its spending on R&D and innovation. Still, there are pundits, mainly economists, who have continued to argue for the type of R&D and innovation strategy advocated by this "2nd generation" strategy, however, now with new labels. One of these carries the label of "Open Innovations" (Chesbrough et al., 2007; 2006), and perhaps by this, attempt to make an association and resemblance to the successful "open source"-movement of the computer science world, i.e. the type of working style and cooperation that has evolved from hackers (Godø, 2002).

According to the tenets of "Open Innovation", firms should enter into co-development partnerships, into what Chesbrough et al. term as "..mutual working relationship between two or more parties aimed at creating and delivering a new product, technology or service" (2007, p. 55). The basics in this prescription is sharing costs and risks with other firms in technology development and innovation activities, and the opportunities of leveraging complementarities in terms of unique expertise and competence from each firm participating in the collaboration. In addition, these types of collaboration will expand the size of a firm's networks. Although one may be sceptical to some of the reasons advocated by the "Open Innovation" model because it violates or underestimates many of the problems that plague collaboration between firms (e.g. transaction costs and trust), there is a deeper, more fundamental reason for why this model has merits – and empirical evidence supports its viability: As technological development, in particular explorative, radical technology development is becoming more and more complex and specialized (and more costly), many development projects are beyond the capabilities of a single firm, even large firms or nations. The GSM development (Godoe, 2000, 2006) and Internet (Mowery & Simcoe, 2002) are examples of successful "open innovation" – maybe for different reasons than Chesbrough would want to point to. In a sense, "Open Innovation" is inevitable as a new type of division of labour in society for creating innovation, in particular radical innovation. For this reason, resent research (Herstad et al.,2008) has suggested that the concept of "Global Open Innovation" is more fertile and accurate. This concept is supported by findings based on analyses of Community Innovation Survey data from four European countries. Accordingly, they suggest that "..it is primarily the overall openness of organisations which impact positively on innovation performance, in addition to intramural R&D and international collaboration within the value chain, i.e. with customers and suppliers" (2008, p. 61). But this is a social system perspective which does not accord with the capitalist assumptions that underlie Chesbrough's advocacy of this concept. Even more, this approach does not really address the fundamental problems that Teece (1988) identified as basic for why R&D and innovation activities are done in-house, i.e. within the firm, and why firms want to maintain control over this type of activity, and how they balance this with their knowledge that there may be advantages in some type of "open innovation"-approach for their firm, such as collaboration with others, even competitors.

In order to understand how and why firms innovate, it may be fertile to have an idea of how firms make decisions on innovation activities. This will be the topic next.

3 How do firms make decisions on innovation activities?

A tangible and convenient approach to this question is to start with an organizational perspective, based on the assumption that decisions on innovation activities may be considered as a type of investment. The term "investment" in this context is used in a broad sense, meaning allocation of resources for a specific purpose[1]. Similar to other types of investments decisions, these may be characterized as either

- *Formal decisions*, i.e. some type of approval (or rejection, which is also a decision) of a plan by a person with authority to make this type of decision, or, more common, some type of collective decision making unit, such as a board or a committee or a group of managers and executives, etc. These types of decisions are typically for approving a budget for a project, or more permanent, an annual budget for some organizational entity that is responsible for some type of innovation activity, such as a permanent R&D facility or product development unit.

- *Informal decisions*, sometimes even experienced as a "non-decision", in the sense that innovation activities are initiated without formal approval from any governing body or person in the firm. However, more often than not, because those initiating the activities have a sense of "understanding", some type of tacit approval or climate that favours these types of initiatives may exist. Extreme cases of informal decisions are those that initiate innovation activities in secret, often after a formal rejection of a project proposal or because those who initiate these types of activities anticipate that the formal mechanism for obtaining approval will end up in a rejection.

Needless to say, many in-between categories exist in the continuum between formal-informal extremes. One common development path in innovation activities is that these are

[1] Firms differ to the extent that these allocations are considered as investments and how they are categorized. One reason for this is that there are technical aspects related to taxation and accounting in this issue: If innovation activities are classified as capital investments they enter into the accounting book as a different category than if they are categorized as operational costs. Innovation activities that are categorized as operational costs are entered into the books as a "normal" expenditure that show up in the annual accounts of a firm, which in some cases make a big difference as to how profitable a firm appears to be, according to the accounts. Many accountants prefer to classify innovation expenses as operational costs because this makes their bookkeeping more convenient and more "visible" as a cost item, as one accountant expressed this. This last point is, in a negative sense, significant, because it often an indication of attitudes and "company culture" related to innovations in a firm. Firms that think and talk about innovations and use the term investments in this context usually have a more strategic view of innovation activities. Those who consider innovation activities an operational cost often equate these types of activities with other cost items, such as salaries, office space rent, etc., i.e. something that should be kept at a minimum in order to make the bottom-line look better.

initiated in small scale as the result of an informal decision, e.g. exploration of some "bright idea". Then, at some point, a more formal plan is made and submitted "upwards" in the system for approval, i.e. a transformation into a formal decision making process. The informal process prior to this type of formalization is sometimes called the "Fuzzy Front-End" of innovation process (Gordon et al., 2008; Koen et al., 2001) because it is often explorative, in the sense that activities at this stage are characterized by search and feasibility analyses. Robert Cooper, responding to a critique that his earlier "Gate-Stage"-process did not recognize the significance and crucial creativity of this early stage of an innovation process, redesigned his model in an attempt to formalize what should be done in relationship to the first stages of an innovation process, what he terms the "Ideation"-stage. (Cooper et al., 2000)

One reason why Cooper and other analysts now advocate more formalism at this early stage is that these types of activities are often viewed with suspicion by management because they are outside formal plans and budgets. Typically controllers and financial management in firms consider these activities to be "fooling around" or "engineers indulging in their technological wet dreams". Imposing formalism, according to these advocates, will give people working with development of innovation activities legitimacy. One experienced, highly recognized research entrepreneur said that he often was forced to act as a "thief", i.e. he "stole" resources from ongoing projects that were approved in order to work on developing new projects that either were in an exploratory stage, or projects that he felt that the "burden of proof" in terms of obtaining formal approval would require much "illicit" homework before he could present this formally.

Although the notion of a formal decision on innovations may be associated with bureaucratic or semi-bureaucratic decision making processes in firms of some size, they are also relevant for small firms, of course, this being dependent on the type of ownership and to what extent shareowners and investors are involved in decision making in the firm. Allocations of resources above certain limits are typically issues that managers need to get some type of approval from a governing body of a firm. Often these are parts of a budget process that need to be approved by a board, or some surveillance authority wants to know about because this is considered relevant information for the stock market. Although the information given may be considered summary and inconsequential, most firms have some type of formalized process for deciding on innovation activities.

According to the findings of the Minnesota Innovation Research Project (MIRP) reported in Van de Ven et al. (1999), decisions on innovations are preceded by what they call the gestation period of an innovation journey. The term "gestation", meaning some type of pregnancy, may extend for many years, "..during which a variety of coincidental events set the stage.." (1999, p. 10) for starting up work on developing a potential innovation. The decision to launch development work and to allocate resources to this is usually triggered by what they call "shocks". These shocks come in many shapes and varieties, either from the inside or outside the organization or the firm, such as "..new leadership, product

failure, a budget crisis, or an impending loss of market share,.." (1999, p. 29). Shocks typically make the organization receptive to ideas and potential actions that will contribute to the sustainability and future profitability of the organization. This is were the "innovation entrepreneur", often also called the "champion", enters the stage with his or her idea or proposal for doing an innovation oriented project. Van de Ven (1999, p. 30) explain this mechanism for initiation of innovation activity in terms of socio-psychological dynamics in human nature and behavior: Necessity, opportunity and dissatisfaction. Accordingly, they suggest that March and Simon's (1958) explanation that dissatisfaction with existing conditions, typically a result of a shock, is a driver that make people search for new solutions that will make improvements: People and firms will pursue this until they once more are satisfied, hence the notion of *satisficing* instead of maximizing as a more fertile understanding of what people do.

At some point, this gestation period, which they also call initiation period, ends and a development period starts. The development period is initiated when some form of formal approval has been given by top managers or venture capitalist, in order to approve allocations of the resources needed for doing the development work. Innovation entrepreneurs and champions typically "oversell" their proposals in order to obtain approvals and resources. Van de Ven et al (1999, p.32) explain that they "..committed themselves to a course of action and set of overly optimistic expectations by investors and corporate sponsors". Inevitably, these expectations are seldom fulfilled. Needless to say, the primary reason for this is that innovation activities are essentially uncertain – it is impossible to plan and anticipate the course of developing something that is unknown; if the course of action had been known, this would not be an innovation activity. Of course, innovation entrepreneurs and champions act opportunistically because they know that if they express their own doubts and uncertainties to their superiors, they will probably not endorse a project proposal. So, they have to make their hopes and visions sound like confident predictions and present a straight-forward, smooth development plan and budget. Because of this Van de Ven use the metaphor of "innovation journey", which they poetically describe as a travel into uncharted territory.

What happens in the course of a development process, specifically how innovation oriented projects evolve, will not be a topic in this paper, however, it is surprising to see a striking similarity in the findings made by many researchers, such as Van de Ven et al. (1999) and Bruno Latour's (1987) observations and analyses of innovation processes. Latour uses a conceptual framework based on his ANT – actor-network-theory where key concepts such as "translations" and "obligatory point of passage" are strategic in his explanations of this process. His model accords well with the findings of MIRP[2] on how innovation oriented projects evolve. Both have found that delays, cost-overruns, unexpected technological hurdles, conflicts and deceptions are typical, making the process chaotic in system dynamic sense – and vulnerable for various types of set-backs.

[2] MIRP = Minnesota Innovation Research Programme

What Van de Ven et al (1999) point to is the crucial role of top managers and venture capitalists in the innovation development process, in particular in the initial start-up phase. According to them, a large number of managers are typically involved: "Thus, the innovation entrepreneurs did not simply report to a single top manager or investor; they were accountable to a team of top managers or a board of investor/owners" (p. 48). Within this, different people played different roles; four distinct roles were identified: Sponsor, critic, mentor and institutional leader – and during development these roles were shifted so that at some point a sponsor would become a critic, etc. This explains why this group of people often had opposing views, hence this "..served as checks and balances on each other in making innovation investment decisions" (p. 48). Although this contradicts an important principle of mainstream innovation management that recommends a coherent and clear innovation strategy such as advocated by the NPDM[3]-guru Robert Cooper (1996), Van de Ven et al. suggest that this pluralism (and ambiguity) is in fact advantageous because decision making in innovation activities may benefit from this: "Pluralistic leadership increases the chances for technological foresights and decreases the likelihood of oversights. Of course, such a pluralistic structure does not ensure intelligent leadership. However, we expect the odds of organizational learning and adaptability to increase when a balance is maintained among dialectical leadership roles throughout innovation development" (1999, p. 124).

Making decisions on start-up of development project is perhaps the most critical type of decision a firm makes in an innovation activity. As typical for any development trajectory, the direction of the development is highly sensitive to initial conditions, so sensitive that seemingly innocuous, small factors will grow and influence the course of development.

One influential approach to decision making in innovation management is portfolio management. An authority in this is the approach advocated by the label of "3rd generation R&D", in a book published in 1991, written by a group of consultants in Arthur D. Little, cf. Roussel et al. (1991). If this book had been written today, the word "innovation" would probably have been included in the title, because the topic of this book is what many companies before called R&D, but now term as innovation. At the time when the book was published, many corporations and companies had closed down their centralized, corporate R&D laboratories; often these were simply shut down because top management believed that R&D, just like any other service, could be obtained on the market "on demand" and that doing R&D was a costly distraction for the firm - it should stick to basics, i.e. core business and competence. In other firms, R&D was split and relegated to various divisions and business units. The ethos motivating this movement was a strong belief in market dynamics, not just in general in society outside the firm, but also inside the firm. This R&D (and innovation) management philosophy Roussel et al (1991) called the "2nd

[3] NPDM = New Product Development Management

generation R&D", which succeeded the "1st generation R&D" in which the large, centralized corporate R&D organizations flourished, with the highly successful and prestigious Bell Labs of AT&T as the epitome of this. By advocating what they termed "3rd generation R&D", they argue that the "2nd generation R&D" had "gone too far" in the sense that firms advocating this would gradually become obsolete and uncompetitive because they had cut off their capability of creating new products, services and processes that would give them competitive advantage – a type of advantage that is not a commodity for sale on markets. With this mild form of criticism of the market oriented R&D philosophy of the "2nd generation R&D", they introduced the portfolio management approach to R&D as method for managing R&D (or innovation) activities in a strategic perspective. In this also, the decision making prior to the start-up of development is seen as crucial and this will now be explained because the book has been influential in how corporate managers think about innovation activities.

The fundamental tenet of "3rd generation R&D" is that R&D should be closely aligned to the firm's business strategy and for this reason should be considered a type of investment, i.e. subject to strategic analyses just like any other large investments that a firm makes for creating future business opportunities. In this view, R&D is part of the firm's total investment; in fact, R&D may be considered as the first step in a long investment process which will eventually result in large investments in production plants and other material capabilities. Because R&D often consists of many projects and activities, all these elements may also be called a portfolio. Based on this, the book presents a number of criteria and decision making rules that top managers should consider for how a R&D portfolio should be made and managed. The most important primary criteria in this is "R&D project attractiveness" that all proposals should be analyzed before they are considered in a broader R&D portfolio perspective. The procedure they advocate is shown in table 2.1

Table 2.1: Typical elements of project attractiveness, according to Roussel et al. (1991, p. 95)

Elements of R&D project attractiveness	**Units in which attractiveness is expressed**
Fit with business or corporate strategy	A judgment ranging from ***excellent to poor***
Inventive merit and strategic importance to the business	The potential power of the sought-after result to: - Improve the competitive position of the business - Be applicable to more than one business - Provide the foundation for new businesses A judgement from ***high to low***
Durability of the competitive advantage sought	***Years:*** If the R&D results can be quickly and easily initiated by competitors, the project is less attractive than one that provides a protected, long-term advantage
Rewards	Usually financial, but sometimes "necessity work" (e.g., satisfying regulatory bodies) or building a knowledge base that becomes the foundation for applied work
Competitive impact of technologies	Base, key, pacing, embryonic: If a project is made up of the application base technologies, it is classified as "base"; if a project contains at least one key or pacing technology, the entire project is classified as "key" or "pacing"
Uncertainty	
Probability of technical success	Probability units, 0.1 – 0.9. The probability that the objective will be achieved as defined
Probability of commercial success	Probability units, 0.1 – 0.9. The probability of commercial success if the project is technically successful
Probability of overall success	Probability units, 0.1 – 0.9. The product of technical and commercial probabilities
Exposure	
R&D costs to completion or key decision point	Amount of money
Time-to-completion or key decision point	Time
Capital and/or marketing investment required to exploit technical success	Amount of money

According to Roussel et al. (1991, p. 96), the first element of attractiveness – fit of the R&D project with business or corporate strategy – is the most fundamental. If the assessment made of this point is positive, e.g. a judgement of "excellent", then one may consider the other elements in the table. For this purpose, they suggest various methods for scoring these, the scale employed and how these are given comparative weight, one may

sum all these and obtain an overall score of each project. Based on these scores, it is easier to make a comparison with other, competing proposals – and for subsequent analyses that will determine how new projects may fit into the firm's existing portfolio and what kind of priority should be given to this in relationship to ongoing projects already in the portfolio. They suggest a number of tools and techniques for doing these types of analyses – and adjustments of the portfolio, e.g. terminating projects that have become less attractive because of poor progress or change of business strategy or priorities, or even giving higher priority to others for the same reasons.

The implication of adopting the methods and thinking advocated in the "3rd generation R&D" is that decision making on innovation activities will be based on rigorous analyses of project proposal, i.e. a type of professionalism in innovation and R&D management that requires analytical skills and a considerable amount of experience and broad expertise in many fields and disciplines. This is often done by senior staff members in an R&D strategy and planning unit, which often acts as a secretariat for various management boards and expert committees that are involved in decision making in large companies. In Norway, this is done in a few large corporations, such as in pharmaceuticals (Godø, 1997; Gulbrandsen & Godø, 2008) and ICT – some even use criteria and methods that seem similar to the ones advocated by Roussel et al. (1991).

In the Stage-Gate approach of Cooper et al. (2000), a rigorous process prior to making decisions on innovation activities is also advocated. Basically, the Stage-Gate approach is a prescriptive model for new product development processes. It depicts this process as linear, in which a number of discrete activities (stages) are linked together in a chain. In the transition from one stage to the next, in the gates, the project will be reviewed by various groups of managers who make "kill" or "go" decisions as to continue ("go") or terminate ("kill") a project. These managers are called "gate-keepers". A copy of the Stage-Gate model is shown in figure 2.1.

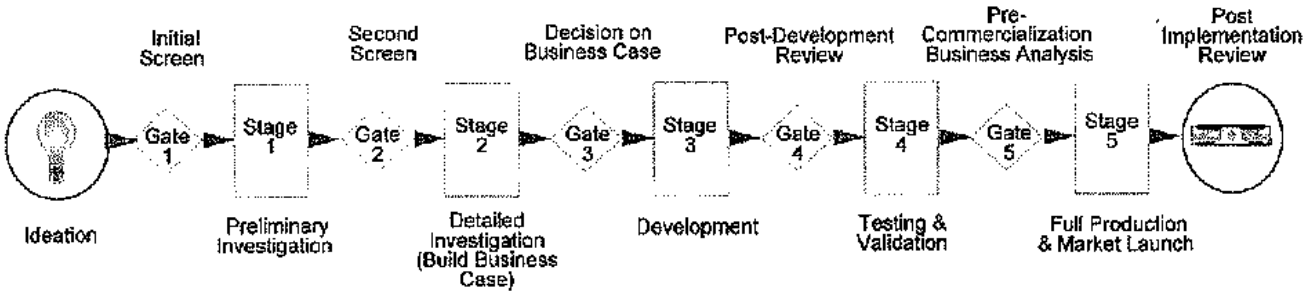


Figure 2.1: A new product development process according to the Stage-Gate model. Source: Cooper et al. (2000, p. 25)

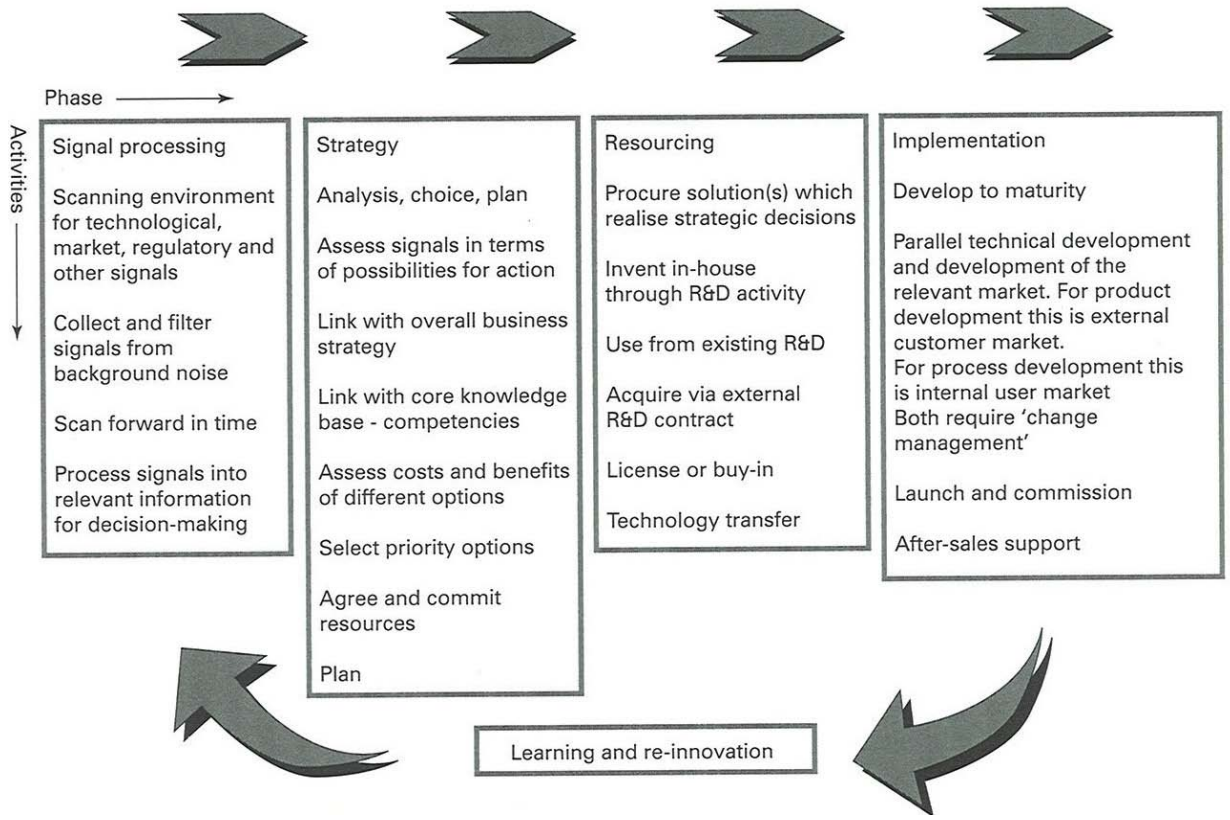
According to this model, decisions on innovation activities are made at each of the first three gates, however, the final decision is made at "Gate 3", after the first two stages "Preliminary investigation" and "Detailed investigation" have been completed and successfully passed the first two gates. The emphasis in this is providing information in a format and types that make it possible for senior management to make priority decisions and decisions related to how the portfolio should be composed. Accordingly: "Every gate has a menu of deliverables – a list of information items that senior management needs in order to make effective Go/Kill decisions at each gate. Thus, project teams are well aware of what information they must deliver; these deliverables become the team's objectives" (2000, p. 24).

In addition to this type of decision-making Cooper et al. (2000) advocate portfolio management, which have many similarities with the advice given by Roussel et al. (1991), however, Cooper et al. (2000) use a more no-nonsense type of language in explaining why this is important: "Portfolio management is a dynamic decision process whereby a business's list of active new product (and R&D) projects is constantly up-dated and revised; new projects are evaluated, selected and prioritized; existing projects are evaluated, selected, killed or de-prioritized; and resources are allocated and re-allocated to the active projects" (2000, p. 27). Cooper et al. (2000) suggest a number of criteria, techniques and practical tools that may be employed for doing this (e.g. check-lists, making NPV-estimates, scoring models, etc.). According to the Stage-Gate model, the portfolio analysis and decisions made at Gate 2 are the most significant for deciding on new product development activities, i.e. innovation activities, because at this point decisions on starting up new activities are made in the context of a portfolio analysis.

When some, more academic innovation theorists, write a book on innovation management, they seem to weigh their words carefully (at least compared to Robert Cooper) in giving advice on how to innovate. One such, Tidd, Bessant & Pavitt (2001, pp. 40-48, 241) perceives challenges in terms of innovation management as consisting of four phases and types of activities:

- Surveillance of environment (internal and external) for potential innovation ideas
- Select the "right" kind of idea
- Allocate resources to development of the idea
- Implement and launch the new idea in the market.

The basics of this is shown in the model in Tidd, Bessant & Pavitt (2001, p. 41).



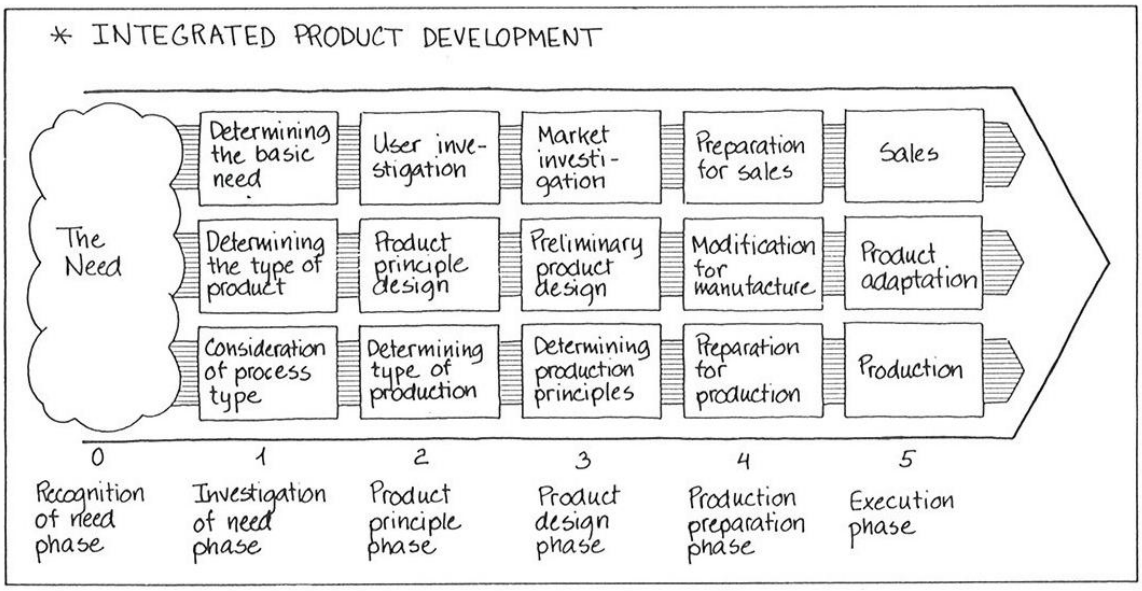
Based on this structure, they – similar to Miller & Floricel (2007) – distance themselves for the "best practice" tradition and instead "..seek to expose the links between the structures, processes and culture of an organization, the opportunity for and characteristics of technological innovation, and the competitive and market environment in which the organization operates" (Tidd et al., 2001, p. 15). Still, they recommend that managers, when they are going to make decisions on innovation activities, consider the following aspects:

- Develop innovation framework based on business strategy
- Develop a strategic concept, which should be clear, tangible – and testable in terms of market, production, design, etc.
- Pilot testing in market places and with technological experts,
- Integrating different perspectives, i.e. establish multidisciplinary groups and use of simulation tools (e.g. rapid prototyping) for evaluation of concepts,
- Involve suppliers and subsystem designers in the process,
- Work with lead users,
- Use screening techniques in selection
- Interact with outside institutions, e.g. surveillance authorities, compliance with standards, etc.

All these admonitions – and many more – bear a close resemblance to what Robert Cooper advices, but without his flow-charts, detailed check-lists and macho language. A "Nordic

model" of the same process puts emphasis on transdisciplinary cooperative working groups in innovation activities as something good, e.g. as depicted in the "integrated product development" concept of Lars Hein and Mogens Myrup Andreasen (2000, p. 23), and a copy of their model is shown below. The reason for this similarity, which is also shared with many other product development theorists, e.g. Ulrich & Eppinger (2000), is that this has become a mainstream approach to product and service development. Accordingly, much of the attention and emphasis is set on selection and decisions related to how ideas for innovation activities should be elicitated, detected, developed and – finally – selected.

What many of these prescriptive types of articles and books have in common is that they offer tangible tools and recipes to managers on how to make decisions on innovation activities. The target audience of this type of literature is managers, those who actually make decisions and work in settings where doing innovation activities is important. Needless to say, this "how-to-do" type of literature is not only prescriptive – it is just as normative in the sense that they advocate that making decisions on innovations should be the result of rational choice and judgment, with the explicit message that profitability of the firm is the most important criteria for this. However, it is possible to identify another type of message, a more veiled message, in this: This is what you should do in order to "beat the system", in the sense that if the prescriptions are followed, then the type of creative activity that innovation is, this will flourish.



Source: Andreasen & Hein (2000)

3.1 Capturing ideas

Many companies have policy measure and mechanisms in addition to the organizational ones described above. One such is to put emphasis on elicitation and capturing of ideas for innovation activities. The basic idea in this is that the main challenge in development of innovations is to obtain and develop "good" ideas for new products, processes and services – and that these ideas often are floating around in the universe outside and inside the firm. Wide arrays of methods are often employed, ranging from systematic market and trend research to various systems of suggestion boxes. Some firms expend many resources on the latter type and have designed systems for collecting, sorting and analyzing various types of input. Although the vast majority of ideas are rejected, those that are selected for further development may be promising for future innovation activities.

Personnel policy is sometimes used for promotion of innovation activities. The rationale of this is that if the firm has high quality employees, they will contribute to the innovativeness of the firm. Recruiting bright, young engineers, scientists and experts is a common strategy for many firms. This is often combined with a personnel policy of keeping the average age of people working with innovation low, i.e. young people are believed to be more creative and innovative than older employees. For this purpose, various incentives (e.g. "career plans") are made so that R&D people or others who work with innovations will be moved over to other parts of the organization as they become older. In one variety of this policy, managers are expected to make annual evaluations of their subordinate's performance and those who are rated as "sub-standard" are encouraged to leave the company. In one company, General Electric, the target is set at 20%, i.e. that each year 20% of the people should at all times be classified as sub-standard and substituted with new and potentially more innovative employees. Over time, according to this policy, the company's manpower will consist of employees who have capabilities to innovate.

3.2 Divisionalization

As pointed out above, the degree of formalism, routines, rules (often called "policy") and procedures related to decision making in innovation activities reflect size and organizational structure of the firm. Large firms, typically multinational corporations, are usually divisionalized; each division is usually an autonomous profit unit with own budgets, investment plans and strategies. The degree of autonomy within a divisionalized firm may differ much. A common characteristic of divisionalized firms is that innovation activities is the responsibility of the division. In some firms, this is even more decentralized, so that units within a division (they are often also autonomous "profit centers") or subsidiary firms "owned" by the division are expected to take care of their own innovation activities. This principle creates numerous strategic paradoxes and tensions in large firms. The basic rationale for this organizational principle is to make sure that innovation activities, specifically R&D, is relevant for its users, i.e. the divisions or units

within a division, because in this type of setup costs for innovation activities are paid by the users or clients within the unit or division doing the innovation activity (Fransman, 1992; Roussel et al., 1991). In Norway, Norsk Hydro introduced this principle in their corporate structure as early as in the 1960s (Andersen & Yttri, 1997), in part because the top management were dissatisfied with what they felt was irrelevant R&D done in their centralized R&D system.

In other words, the tenets of this way of organizing innovation activities is that "users" should be responsible for innovation activities and for making adequate resources available for doing this. Hence, formal decisions on innovation activities are taken by the top management of divisions, or by the leaders of profit centers or subsidiaries, if they are given this type of autonomy and responsibility. Coupling and alignment of innovation activity with business strategy is of course a very sensible idea for a number of other reasons, such as presumably more efficient communication because of organizational proximity (including the trust factor) and ease of knowledge flow. However, the strength of this principle is also its weakness: Because of its focus on innovation activities related to existing products or services and the political power that controls these activities, they will tend to favour incremental innovations, i.e. favour activities that make minor improvements on the existing product portfolio and services – and relate themselves to existing market segments. In other words, the firm will gradually become conservative and minimize innovation activities because the incentives in a divisionalized structure is to keep all kind of costs as low as possible; the bottom-line is the main success criteria for managers and executives. In sum, this may result in a sub-optimal strategy for the firm. This is widely recognized and acknowledged and explains why many firms have enacted strategies to counter-balance this.

One common strategy for counter-balancing innovation conservatism in divisionalized firms is to allow for and actively encourage some type and degree of "free" innovation activity. There are numerous ways of doing this, however, allocation of resources to this type of activity is usually made at the corporate level by some kind of policy decision. One typical policy states that 10% of the allocations to R&D should be given to projects that explore new business and technological opportunities, i.e. "new" often meaning that these opportunities are perceived to be outside the corporation's current line of businesses. This may be financed by the levy of a "R&D and innovation tax" on divisions, as an element of their corporate financial contribution. In exchange for this, divisions may be given a membership in the committee that decides on these types of corporate innovation projects. These committees make recommendations, often following a rigorous research council type of procedure, to the board of executive, who make the final approval and allocations. In some corporations, outside experts, often highly recognized academics, are asked to become members, in order to boost the legitimacy and innovativeness of decisions and in order to have pipelines and networks to outside R&D communities (Godø, 1997). In these types of corporate policies, a typical statement that is often made may be this: "It is a

corporate responsibility to ensure the long-term viability and profitability of our firm through innovations in the markets".

There are numerous ways of implementing the type of "free" innovation activity described above. Some firms have corporate R&D units which take care of this type of research, but this is controversial because many executives think that these units are "useless"; they think that corporate scientist like to do "blue sky" research and have academic ambitions, i.e. have agendas that are not compatible with the firm's business strategy and needs. In some firms, projects financed by corporate money are "given" to R&D or product development units in divisions. A more novel model is to create "virtual R&D organizations" composed of participants from the whole corporation (Gulbrandsen & Godoe, 2008). This is often used in multinational corporations where innovation activities are geographically dispersed and highly heterogeneous in terms of competencies and market conditions.

3.3 Temporal cycles in decision-making

As organizations, firms follow a temporal rhythm in terms of decisions on innovation activities. Typically, decisions on innovations are closely aligned with budgetary processes in the firm. In most companies, budgets for the next year are made during the autumn. There are of course numerous sources for input to these budgets, but often the firm's strategy play an important role. Activities related to strategy are typical early year or spring-time activities; an important input to these is the accounts and results from the last year. The types of analyses that are presented in strategy processes relate to issues on innovation activities. A typical outcome of such a process may be consensus on the importance of a new direction – and that some type of activity relevant for this should be initiated. In Japanese firms, the budgetary year starts (and ends) on 1st of April, but the implications of this phase discord compared to the rest of the world has not been analyzed.

4 Structural perspectives on innovation activities

In analyzing how firms do their innovation activities, there are two general perspectives or factors that seem to be influential:

- Size of the firm, and closely related to this, geographical extension of the firm, and
- Policy and/or strategy cycles.

Both factors are often closely related to the diffuse, but nevertheless important factor of "firm culture" and identity, but this topic will not be discussed in the following. Just how size and cycles of strategy and policy interact is also a matter of interest, but this is also a challenging topic because it is difficult to observer and specify just how these factors interact, i.e. how they manifest themselves empirically and what kind of causalities or dynamics are involved. This may explain why research literature on this topic is scarce and tentative.

Size and geographical extension are structural factors that are closely aligned. This, as pointed out, is an important aspect in how decisions on innovation activities are made. According to one study (Tirpak et al., 2006), one may observe a correlation between size, as measured by the number of employees and volume of revenues of a firm, and how they organize their innovation activities, in particular R&D: "Small" companies, e.g. firms with less than 1,000 employees, more often than not, have a concentration of their innovation activities in and around one centralized R&D unit that has the main responsibility for doing innovations related activities, typically, such as product development. As the company size increases, decentralization and distribution becomes more common.

Modern firms typically cope with growing size of their firm by divisionalizing their organization, for a number of reasons: The most important reason is to make various parts of the company more flexible and agile, while at the same time make each unit more accountable and focused on obtaining value creation and results. The common (and real) fear is that as the organization grows in size, it may quickly become bureaucratic, inefficient and loose its business acumen. As discussed elsewhere in this paper, when divisionalization is introduced, innovation activities are also often divisionalized, which in many companies means that formerly centralized R&D entities are split up and distributed to various divisions. De facto, a similar process occurs when firms establish subsidiaries or expand into other countries and (for them) new markets. This may also be done for additional reasons: A new R&D site or similar type of entity responsible for innovation activities in the "new" country may be needed in order to do product development for local market adjustments, but also for establishing networks with local knowledge communities and for long-term recruiting of local talent in the country they want to grow in (Gulbrandsen & Godoe, 2008). This picture becomes complex because often geographical expansion is done by mergers and acquisitions – and all of a sudden the mother company

may find itself owning a R&D facility that came along with the company that was taken over. Sometimes these are closed down in order to create what in corporate language is often described as “synergy effects”, but another option is to introduce “corporate policies” that assign “corporate responsibility” for a particular type of product or technology, i.e. some type of division of labour and specialization is introduced, as seen i large corporations such as ABB.

However, as the company (or corporation) grows even larger (and becomes truly multinational), a hybrid type of organization of innovation activities seem to become prevalent. According to Tirpak et al. (2006), this type of organization seem to emerge when the company has more than 10,000 employees and/or has passed the US$ 5 billion mark in terms of revenues. This is termed “hybrid” because companies often re-establish some type of centralized R&D activity closely affiliated with the corporate headquarters, while maintaining the decentralized system of innovation activities and R&D in the divisions, i.e. the divisions continue to have responsibility for innovation activities in their “spheres of interest”. Tirpak et al. explain this: “Today the pendulum appears to be swinging back toward centralization, not because there is less short-term pressure but because companies have largely used up their “seed corn”, i.e. new ideas and technologies enabling them to grow the enterprise” (2006, p. 23-24).

This explanation fits well with what has been expressed by some CEOs, as reported in interviews, cf. Gulbrandsen & Godoe (2008), i.e. that they should have some capability within the organization to anticipate and explore technological and market opportunities that may represent new business and potential threats to their existing business models. This strategy also fits with the observations that large corporations often pursue “second mover” strategies (Gilbertand & Bormbaum-More, 1996; Nerdrum & Godoe, 2006), i.e. that they expend resources on surveillance in terms of technological and market trends in order to respond quickly if and when competitors or new entrants launch new products or services that may be superior to their own. As long as a large corporation is a market leader, it will favour incremental innovation activities that support its existing product or service portfolio; it will not take the risks and burdens of being a first mover. Hence, they allocate “corporate money” for what they euphemistically often term as “free R&D”, i.e. explorative innovation activities and associated scouting. As discussed elsewhere in this paper, this may be done in a number of different organizational solutions.

5 Cycles in strategy and policy

Decision-making on R&D and innovation activities is somewhat related to the question of cycles in innovation strategies, more specifically to what some theorists have termed as the oscillation between "exploration" and "exploitation" strategies – and terms that are synonymous with this. These two concepts depict firm level behavioural implications of what may broadly be called policy thinking and decision making relevant for innovation activities. James March defined and elaborated these concepts in a seminal article in which exploration was explained as activities related to "..search, variation, risk taking, experimentation, play, flexibility, discovery, innovation" (1991, p. 71). In contrast, exploitation is activities related to "..refinement, choice, production, efficiency, selection, implementation, execution". March elaborates this by suggesting that "Both exploration and exploitation are essential for organizations, but they compete for scarce resources" (1991, p. 71). However, this is essentially a distinction between "..refinement on an existing technology and invention of a new one" (1991, p. 72), i.e. what may be termed as a strategy for pursuit of incremental innovations vs. radical innovations. In the hybrid organizational model that large corporations tend to adopt, establishment of these "hybrids" may be interpreted as an attempt to reconcile these two opposing strategic directions.

In Van de Ven et al. (1999, p. 184-191), this fundamental dichotomy is relabeled as a cycle of "divergence" behavior, and contrasted with "convergence" behavior of the firm. Both are steered by constraining factors and enabling factors. Divergence, which is close to March's concept of exploration, "..involves branching behavior that explores and expands in different directions" (1999, p. 184). Its attributes are: Creating ideas and strategies, learning by discovery, pluralistic leadership, building relationships and porous networks – and creating infrastructures for collective advantage. The latter may include R&D collaboration with other firms or universities, or participation in standard setting activities, etc. This type of activity is characterized as "running in packs". In contrast to divergence, convergence behavior, which resembles March's term exploitation, is a strategy of "..integrating and narrowing...that focuses on testing and exploiting a given direction" (1999, p. 185). Its attributes are: Implementing ideas and strategies, learning by testing (trail and error), unitary leadership, executing relationships in established networks – and operating within infrastructures for competitive advantage. In Van de Ven et al (1999), these concepts, as factors that drive innovation activities, are seen as dynamic in a chaos system perspective, i.e. within a strict mathematical understanding of chaos as a nonlinear dynamic system. Accordingly, development is seen as following a predictable pattern, although it may be difficult to make exact predictions of the individual path of each case, somewhat similar to a cyclone drifting erratically across the globe, yet in a general direction. This, according to Van de Ven, sets the course of development of an innovation activity, hence their depiction of this with the metaphor "innovation journey": "The journey entails maneuvering through stretches of divergent and convergent waters" (1999,

p. 213). So their advice to managers is that they should master both types of behavior – and should be capable of recognizing situations where one strategy should be chosen instead of another.

March (1991) makes a simulation of how organizations that follow either "exploration" or "exploitation" develop over time. He suggests that the exploitation strategy will give results that are "..positive, proximate, and predictable", whereas for exploration, the results "..uncertain, distant, and often negative" (1991, p. 85). Accordingly, the burden of proof for explorative strategies are much more challenging than for exploitation, which may explain a bias for short-term strategies. This aspect is not addressed in Van de Ven (1999), but in both, the temporal dimension is long, development over years.

If we accept the usefulness of concepts such as divergence/exploration and its contrast convergence/exploitation as relevant for explaining innovation activities, it also becomes relevant to ask how this is translated or embedded in decisions firms make on innovation activities. How do managers make decisions? Clearly, they do not think in terms of abstract concepts such as "convergence" or "divergence", but probably more in terms and concepts that are relevant for articulating and promoting their interests and understanding of what should be done in terms of innovation activities, and, of course conveying this in discussions with peers and power-holder in their organization, who may be rivals and opponents. This then points to how decision-makers (usually managers) think about and understand the role of innovation activities in their organizations, which is a topic we ask informant about in the MINE Norway survey. This and other results from the survey will be reported in other papers from the project.

6 Systemic approaches

Concepts such as convergence/divergence point to factors that influence or are at play in innovation activities, i.e. outcomes of decisions on innovation activities. In this, the notion of "innovation journey" competes with notions such as "innovation games", "technological regimes" and "innovation regimes". To varying degree, these concepts may also be seen as representing systemic models for explaining innovation behavior and activities of firms. The basic idea is that understanding how a system works will also provide explanation of how and why actors make decisions. Within innovation theory, the conceptual framework of sectorial systems of innovation is perhaps most interesting (Godoe & Nygaard, 2006). In the sectorial systems of innovations approach, the concept of technological regime is defined and used in two somewhat divergent ways: one technology studies approach, and second, an economics of innovation approach. Elucidation of this is relevant for understanding these two nuances:

In the *technology studies approach*, the main focus is set on the technology itself and its environment. Rip and Kemp (1998, p. 340), using this approach, define technological regime as "…the rule-set or grammar embedded in a complex of engineering practices, production process technologies, product characteristics, skills and procedures, ways of handling relevant artefacts and persons, way of defining problems; all of them embedded in institutions and infrastructures". Within this type of notion, some theorists have developed the concept of *dominant design* (Abernathy & Clark, 1985; Utterbach & Suarez, 1993) to designate an observed technological stability and predictability in the development patterns, what others call *technological trajectory* (Dosi, 1988) or *technological signposts* (Sahal, 1985).

In the *economics of innovation approach*, more emphasis is put on understanding the economic relationship between the innovating firms (e.g. in a sector) and their environment. Of course, technology is very basic in this approach too (cf. (Malerba, 2004); technological characteristics are the most important dimension in distinguishing one sector from the other. In this, some theorists (Breschi & Malerba, 1997) set focus on four factors, or attributes, which they suggest are important in differentiating sectoral systems of innovations and for explaining salient features of each sector in terms of how innovations are made:

- Opportunity conditions related to profit expectations, which may differ according to:
    - Level, i.e. scale of high to low
    - Variety, i.e. large or little variety in technological solutions
    - Pervasiveness, i.e. scale of high to low
    - Sources, i.e. open vs. closed, and many vs. few
- Appropriability conditions, i.e. the capability or the degree to which an innovation or invention may obtain protection; this dimension may be differentiated in a scale of high (e.g. patents) to low.

- Cumulativeness of technological knowledge, i.e. the possibility of building a reservoir of knowledge – and the ability to exploit this for development of innovations.
- Nature of relevant knowledge base, i.e. inherent characteristics and qualities related to the required knowledgebase, e.g. if these are "open", complex (expert knowledge) or tacit.

Although both approaches to sectorial systems of innovations are fertile for explaining innovation dynamics within a technological regime, neither approach is capable of explaining how a new sector emerges and establishes a new technological regime. This is relevant for the discussion of exploitation vs. exploration, because one interpretation may be that the concept of technological regimes uses criteria that are biased towards exploitation (convergence) type of thinking. In this way, one may provide interesting explanations of a particular technological regime, but not why it changes or why and how new technological regimes emerge.

Often radical technological innovations constitute a central element in the establishment of a new technological regime and a new sectorial system of innovations, as evident in the role of GSM in the growth of a mobile communications sector. In the creation of these radical innovations, strong innovation regimes outside established technological regimes often play an important role. The creation of GSM and Internet as radical innovations emerged from such innovation regimes. In the case of GSM, the relevant innovation regimes were constituted by actors in what subsequently became the ICT-sector, i.e. the fusion of the computer technology industry with the telecommunications industry (H. W. Chesbrough & Teece, 1996; Godoe, 2000). Whereas in Europe, standardization organizations such as ETSI and CEPT played an important role in the development of GSM, in USA, the office of DARPA was important as organizer and catalyser for the development of Internet (Mowery & Simcoe, 2002).

The role of technological regimes and innovation regimes may be considered as contextual factor, i.e. factors that Van de Ven et al. (1999) possibly would classify as constraining and enabling factors that frame innovation behaviour and decision-making in terms of convergence and divergence. From an analytical point of view, one could say that this type of systemic approach may provide a logic or explanation on a general level as to outcomes of innovation behaviour and related decision-making. Providing this type of logic is also the ambition of the conceptual framework of "Innovation Games", which in many ways bears resemblance to the systemic theories presented above, but this will be the next topic.

7 The conceptual framework of “Innovation Games”

In the research done in the MINE-project, one of the published papers (Miller & Floricel, 2007) presents a review of the literature relevant for exploring and analyzing the conceptual framework of “innovation games”. In their approach, they have structured this into what they call “three theoretical pillars” of relevant innovation studies:

- research on innovation systems,
- theories about the role of shared cognitive frameworks in structuring social systems,
- research on the sources of heterogeneity in innovation processes.

Of these, the most relevant in terms of answering the question of how firms make decisions on innovation activities is the second one, the one about the role of shared cognitive framework in structuring social systems, because these are related to actions and action rules. Miller and Floricel explain that this type of research is relevant because they focus on “..decision-making processes that, together with a capacity base, enable managers to develop and implement innovation strategies” (Miller & Floricel, 2007, p. 8). Accordingly, rules and conventions that prescribe what to do may provide blueprint for what kind of decisions that are actually made. Some of these are general and shared by “everyone” within a culture or a society.

According to Miller & Floricel, there are more specific “rule of games”, i.e. that each type of innovation game have sets of “rules” that are unique for the firms that participate in these. This assumption is also part of the conceptual framework of technological regimes. In their mind, rules of the game “..offer a clear path to implementation” in terms of innovation activities, which explains their suggestion that “..rather than recommending concrete strategies and investments, the rules state ideal propensities to innovate and to create barriers, attack, or cooperate” (2007, p. 9). In justifying this, they attempt to make an analogy to Ludwig Wittgenstein’s (1889-1951) notion of grammar, i.e. “rules” that are embedded in a language and that people have to adhere to when they communicate. For this reason, the “rules of the game” approach has more explanatory power than those that explain innovation activities in terms of life-cycles or waves (e.g. Schumpeter (1934 (1974)), Perez (2002)), or evolutionary, systemic approaches (e.g. Edquist et al. (2004) and Lundvall (1992)). The role of rules in an innovation game is, according to Miller & Floricel that of forming a “..coherent totality around the value creation process” (p. 10) – and this also explains the dynamic that is active in generation of heterogeneity. Accordingly, understanding innovations is a matter of understanding how firms interpret and apply rules when they play their game. These rules seem to emerge from contextual conditions that are variable; these variations may in turn determine what type of game that emerge. There are three dimensions in these:

- knowledge production dynamics, i.e. the flow of new, relevant knowledge,
- structuring potential, i.e. the potential for firms to capture value

- demand specificity, which refers to what type of demand and purchasing powers that customers have.

In their model, these three dimensions are put on a tripartite, ordinal scale (high-average-low) matrix – and various combinations of the three dimensions and their value on the ordinal scale define different games. In theory, this may provide 27 different categories of innovation games, however, Miller & Floricel (2007) have identified 11 distinct games. In an earlier paper (Miller & Floricel, 2004), only eight games were presented, which means that criteria for what constitutes a game is flexible. In this latter, earlier article, distinction was made between five fast (rapid) games of innovation and three slow games of innovation. Below, these will be briefly presented, first the five fast games, and then the three slow games of innovation:

1. ***Battles for Architecture***: Telecom services and equipment, B2B and mass market software, electronic test and measurement equipment. Salient aspects of this game are:
    - Value created by coordinating with other players
    - Struggle for de facto standardization
2. ***Races to the Patent and Regulatory Offices:*** Biotechnology. Salient aspects of this game are:
    - Create intellectual property
    - Ability to productize university research or IPR and manage regulatory processes
3. ***Delivering Safe Science-based Products:*** Pharmaceuticals, agro-biotech, medical devices, and home appliances. Salient aspects of this game are:
    - Productizing academic research
    - Deliver absolutely reliable & safe products; cost-efficiency
4. ***System Design and Consulting Services:*** MIS consulting and design, consulting and research for power systems, telecom research services, office equipment. Salient aspects of this game are:
    - Design systemic architecture with dominant or emerging standards
    - Propose integration with hardware, software tools and communication protocols – act as knowledge clearinghouses
5. ***Research, Development and Engineering Products and Services:*** Computer modeling, drug research and discovery, specialty cosmetic ingredients research. Salient aspects of this game are:

- Transform learning from leading-edge customers and universities into products and services
- Anticipate and understand complex needs of their services

According to Miller & Floricel (2004), they found three slow games of innovation. These were:

1. ***Delivering Workable Solutions in Packs:*** Chemical products, industrial gas products, packaging materials, building materials, pharmaceutical ingredients. Salient aspects of this game are:
   - Neither rapid scientific nor technological change
   - Deliver large-scale and problem-free solutions to industrial customers
   - Firms invest in IPR-management & cooperate with customers and partners
2. ***Asset-Specific Problem Solving:*** Cement, electric utility, pulp & paper, petro-chemicals, mining & oil extraction, water treatment. Salient aspects of this game are:
   - Capital-intensive sectors
   - Productivity, quality and customer service important
   - Optimalization and continuous cost reduction
3. ***Customized High-Tech Craft:*** Industrial controls and equipment, engineering design tools, specialty food ingredients, specialty chemicals, electronic equipment. Salient aspects of this game are:
   - Slow technical change, moderate institutionalization, very demanding clients
   - Understanding needs of expert clients
   - Delivering customized solutions compatible with existing solutions – reliability and cost reduction

According to the conceptual framework of "games of innovation", each game has what Miller & Floricel (2004, 2007) call a "dominant logic" for value creation – and, more interesting for us – rules that determine how innovation activities should be organized, i.e. organizational forms that are related to the contextual conditions and "dominant logic of value-creation". Hence, they spell out four sets of rules:

- Innovation capability in terms of knowledge, engineering and management, and ability to transform and commercialize scientific knowledge,
- Network skills, i.e. building relationships to external parties such as customers, investors, competitors, regulators, etc.,
- Competitive and collaboration strategies, which influence allocation of resources to doing innovation activities such as R&D and/or collaboration with other firms.

Depending on what type of game the firm participates in, the R&D intensity for some is in the range of 40% of their revenues, while in others, this may be as low as 1-2 % of the revenues.
- Internal organization of innovation activities, which varies according to what type of game the firm is playing. In some, innovation activities play an important role and have attention of top management; in others, this is something "taken care of" by some obscure R&D unit in the firm.

According to Miller & Floricel, the conceptual framework of innovation games is an evolutionary model, hence dynamics of evolution are relevant for how they develop. In this, there are three key concepts:
- *variation,* which is created by individual and corporate agents (2007, p. 25); in particular entrepreneurs play an important role in creating variation, but the rate of knowledge production is also an important source,
- *selection,* which occurs because of the competition between ideas, technologies and firms,
- *retention,* in which rules become institutionalized and create various types of path dependencies that constitute developmental trajectories.

Looking more closely at the theoretical explanations given for justifying the conceptual framework of innovation games, the ambition seems eclectic, in the sense that they have attempted to assemble elements from a number of different theories on innovation for explaining something that resembles explanations that have been developed within the framework of sectorial systems of innovaton (Godø, 2008). Miller and Floricel are explicit in pointing out that their use of the term "game" has nothing to do with the mathematical understanding such as in "game theory", but their use of "game" as a metaphor has been inspired from sports, such as a game of soccer, where teams are the metaphorical equivalent of firms. In this way, one may suggest that their justification for doing the MINE-survey in which the purpose is to map how managers of innovation activities perceive and judge different aspects related to innovation may be parallel to asking a captain or a team coach of a sports team. The latter point is not spelt out or explained in this way, but it seems to be a fair interpretation of their suggestion that they want to "..identify the rules of the game by measuring and comparing managers' cognitive representations of the value-creation network, participants and roles, strategies and practices" (Miller & Floricel, 2007, p. 28).

8 Modes of knowledge and innovation

One way that organizations differ in terms of innovation activities and how they make decisions on these, is the role of knowledge and mode of innovation. This topic has been explored by theorists who suggest that innovation activities and the way these are implemented and carried out (mode of innovation) depend on, or interact with, the type of knowledge that is used – and how this knowledge is produced, i.e. developed, obtained, adapted and refined. In 1994, a group of researchers led by Michael Gibbons published a book (Gibbons et al., 1994) suggesting that two, qualitatively different, yet equally non-trivial modes of knowledge production now co-exist in modern societies: Mode 1, which is the traditional academic type of knowledge production, and Mode 2. The latter type of knowledge production is created in the "context of application", i.e. most commonly in organizations and settings outside academia. This type of knowledge is created for solving problems that are non-trivial, more often than not because existing knowledge does not provide solutions for these. The book instigated an intense debate which has not yet abated (cf. Godoe, 2007; Hessels & van Lente, 2008), but the idea of Mode 2 may be interpreted as having relevance in explaining innovation activities. A more elaborate approach to the same issue of knowledge production has been suggested by Asheim and Gertler (2005) in a conceptual framework in which distinction is made between three broad categories of knowledge:

- *Analytical knowledge*, i.e. knowledge based on scientific methods and codified information
- *Synthetic knowledge*, i.e. knowledge based on experience and learning-by-doing, tacit type of knowledge
- *Symbolic knowledge*, i.e. knowledge conveying emotional and immaterial values, normally reserved for cultural and artistic enterprises.

The first category of knowledge, analytical knowledge, is similar to what others call STI-mode of knowledge, STI being an acronym from Science, Technology and Innovation. STI-mode is seen in contrast with DUI-mode; DUI is an acronym for Doing, Using and Interacting. DUI has resemblance with the category synthetic knowledge. In an oral presentation of the paper (Jensen et al., 2007) which presents research done for exploring these two concepts, one of its authors, Bengt-Åke Lundvall, said that the STI-DUI dichotomy is different from the Mode 1 and Mode 2 dichotomy, because STI and DUI mostly concerns different ways of doing innovations within the domain of what Gibbons et al. (1994) would call Mode 2-type of knowledge production[4]. In Jensen et al. (2007), the results from a large survey in Denmark (DISKO) is presented. As indicators of DUI-mode, the following attributes were used as identifiers:

- interdisciplinary work groups
- quality circles

- system for collecting proposals
- autonomous groups
- integration of functions
- softened demarcations between employees groups
- cooperation with customers

The attributes listed above are important elements in the IPD-model of Hein and Andreassen presented elsewhere (Andreasen & Hein, 2000) in this paper, which in many ways should not come as a surprise because both originated in Denmark. As identifiers of STI-mode, the following attributes were used as identifiers in analyzing the results from the DISKO-survey:

- expenditure of R&D as a share of total revenues
- cooperation with researchers at universities or scientific institutes
- workforce composition, i.e. its share of scientifically trained personnel

Based on an analysis of their material, Jensen et al. (2007) found that firms that have pursuing a mixed strategy "..combining the two modes [i.e. DUI and STI] tend to perform significantly better than those relying predominantly on one mode or the other" (2007, p. 689). This interpretation is significant because of its compatibility with the four basic "rules" that are associated with the conceptual framework for "innovation games" (Miller & Floricel, 2007) reviewed earlier. However, it is also significant because it provides an approach and strategy for understanding innovation performance in firms: If we are able to identify and characterize what type or combinations of knowledge that a firm develops and uses, we should also be able to understand and predict the "hows" and "whys" of their mode of innovation.

[4] This explanation was given during a seminar in Oslo, 30 October 2007, but I think this is not convincing because it contradicts some of the tenets of Gibbons et al. (1994) definition of Mode 1.

9 Discussion and research agenda

In the research literature on how firms make decisions on innovation activities, a number of competing, yet essentially similar explanations seem to co-exist. They seem competing because different terms, concepts, styles and approaches are used, hence they also seem distinct, so different that at first glance they appear to be in disagreement and contradiction with each other. But a closer look at these show that the differences may indeed be superficial, somewhat similar to the differences between various brands of toothpaste: They are essentially identical in substance but come with slightly different flavour and packaging. An example of this was seen in comparing March's (1991) concepts of exploitation and exploration with Van de Ven et al.'s (1999) notion of divergence and convergence in innovation strategy cycles and policies. Similarly, the conceptual framework of "innovation games" (Tirpak et al., 2006) has many similarities with the concept of "technological regimes", more so than differences of nuances that make them appear as distinct.

Still, there are distinct differences in terms of the intent of this literature and the kinds of discourses that these present. The literature that has prescriptive intent, i.e. books and articles that have a clear message of "dos" and "don'ts" to the manager in terms of how they should manage innovation activities and strategies in "real life" product development processes are clearly different from those that have a normative or ontological intent. In fact, researchers such as Van de Ven et al. (1999) and Bruno Latour (1987) seem to relish the discrepancy between "textbook ideals" of how innovation activities should be carried out – and the empirical reality of what actually happens in firms during innovation processes. The systemic approaches attempt to explain this as the result of a complex set of factors that in sum constitutes a system, e.g. a technological regime, which in turn explains outcomes of decisions and processes. In the conceptual framework of "innovation journey" (Van de Ven et al., 1999) and "innovation games" (Tirpak et al., 2006), innovation processes are viewed and explained as a complex interaction between structural, systemic characteristics (contextual factors) and dynamics related to creating something new for markets. Although both approaches, "innovation games" and "innovation journey" provide profound insights as to how innovation activities are carried out, Miller and Floricel's (2007) presentation of a "dominant logic" for a specific innovation game and the set of rules that are relevant in these, seem to capture the most important factors in innovation activities. These were, as pointed out earlier:

- *Innovation capability* in terms of knowledge, engineering and management, and ability to transform and commercialize scientific knowledge,
- *Network skills,* i.e. building relationships to external parties such as customers, investors, competitors, regulators, etc.,
- *Competitive and collaboration strategies,* which influence allocation of resources to doing innovation activities such as R&D and/or collaboration with other firms.

- *Internal organization of innovation activities*, which varies according to what type of game the firm is playing.

Although these factors provide an adequate framework for analyzing and understanding innovation processes, they do not provide understanding for how and why initial decisions on innovation activities are made. The crux of the matter seems to be what happens in the "Fuzzy Front End" of an innovation process, or what Van de Ven et. Al (1999) calls the "gestation period" that precedes a decision to start up innovation activities, in the early, yet crucial initial period in the innovation process. Research point to this period more as a play, more often than not, highly informal processes, in which innovation entrepreneurs are active. If the innovation entrepreneurs are "successful" this may end up as a formal decision that starts up an innovation activity, a product development process or project. Typically, the formal decision is made by top management, various boards and committees, owners and investors. They negotiate, argue, manipulate, make alliances in the way that Van de Ven et al calls "pluralistic leadership" (1999, p. 48). Four roles were identified: Sponsor, critic, mentor and institutional leader – and these roles were passed around among the power-holders in the firms.

Although most innovation research – including the highly prescriptive literature on product development processes – seem to agree that this early stage of an innovation process is important, even essential and crucial for a number of reasons, our understanding of what happens at this stage is not satisfactory. Using Cooper's terminology, one may ask: Is a "go"-decision made because of "gut feelings" among managers? Are decisions as "rationalist" as prescribed by textbooks? How do more ulterior, aesthetic factors influence decisions? How much are decisions made because of the charisma and rhetorical and political skills of innovation entrepreneurs and champions?

The next step in researching some of the questions asked above will be to explore and analyze the material from the MINE-survey. This will provide data on the four "sets of rules" that were pointed out above – and by this provide an empirical framework for probing further into the questions asked on what happens when decisions on innovation activities are made – and what explains the outcomes of these decisions, i.e. why specific decisions are made.

Although interesting results and new insights may be obtained from this type of analysis, this will only provide some general, approximate insights. Still, these will give important knowledge and – possibly – tentative explanations of how firms make decisions on innovation activities, i.e. what happens during the "gestation period" or in the "Fuzzy Front-End" of an innovation process. In many ways, this appears to be a "black-box" within the "black-box" of innovation processes in firms and organizations. Asking managers about this process will probably provide answers that accord well with technical-economic rationales of how innovations should be managed. From different perspectives and theoretical approaches, some research suggest that a number of other, less well defined

and understood tacit factors may play an important role: Few, if any contemporary innovation research seem to recognize the role of serendipity and aesthetics as a factor in innovation processes, although many inventors and innovators suggest this is significant in their work (Andel, 1994; Roberts, 1989). One could add to this the role of playfulness and intuition (Basalla, 1988; Ferguson, 1993), as epitomized in the notion of *homo ludens*. Although the concept and role of "entrepreneur" or "champion" often alludes to these attributes as a salient feature of their personality, they are not made explicit as factors in the research on innovation processes. One reason for this may be that these factors are difficult to research, possibly because many researchers have no training in how to approach such phenomena (i.e. they are economists, engineers, etc). However, instead of ignoring these factors and consider them irrelevant or "anecdotal", one should probe further into this matter, in order to analyze to what extent these influence and shape activities and outcomes in the embryonic, yet crucial phase of innovation processes. Then this should become an important goal for future research.

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