Search Pathways to Innovation[1]

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Abstract

Organizational search processes is an important source of firm level heterogeneity in evolutionary - behavioural theory. Combining insights from established and recent evolutionary-behavioural theory we propose that R&D and managerial perceptions constitute two distinct search pathways to innovation. R&D is in this context a measure of institutionalized routine based search, while managerial perception of problems captures situational and cognitive search. Using a new survey of industrial enterprises we find that these search pathways are related to product, process, organizational and market innovation at the firm level, although in a diverse way.

Keywords: Search, innovation

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1. Introduction

It is a "core" notion in evolutionary theory that firms pursue different learning activities, use different types of knowledge in the innovation process, and hence pursue different approaches to innovation (Nelson & Winter, 1982; Nelson, 1991; Nelson, 1995; Winter, 1984). Empirical analysis of these issues is lacking however. Recent theoretical advances in evolutionary economics have a loose empirical foundation (Fagerberg (2003). This is a shortcoming in a discipline where appreciative theorizing based upon empirical studies has been a defining feature (see Nelson & Winter, 1982; Nelson, 1995; Fagerberg, 2003; Fagerberg & Verspagen, 2002).

In this paper we explore the range of search channels firms use in the innovation process and whether different search channels are related to different innovation outcomes. This is important because organizational search processes is an important source of firm level heterogeneity in evolutionary and behavioural theory (Nelson & Winter, 1982; Laursen, 2008; Ahuja, 2002; Katila & Ahuja, 2002; Argote & Greve, 2007; Gavetti & Levinthal, 2000). Our objective is to analyse firm heterogeneity and relate this observed variety to different kinds of outcomes from the innovation process. In order to do so we focus on the learning activities (R&D) firms undertake in the innovation search process and the perceptions firms and their managers have in this regard. Both R&D and perceptions are in our theoretical framework empirical manifestations of organizational search processes for (different kinds of) innovations.

Research and development (R&D) play an important role in evolutionary accounts of firm heterogeneity and has frequently been used as a measure of search activity in theoretical research (Nelson, 1961; Nelson & Winter, 1982; March, 1991). This is because R&D is a

measure of non-codified learning and tacit knowledge (Arora & Gambardella, 1990; Helfat, 1994). Non-codified learning and tacit knowledge is an important source of differences in performance and profitability across firms over time, mainly due to the persistence in the amount and type of R&D conducted at the firm level (Teece et al, 1997; Barney, 1991; Rumelt, 1991; Macpherson & Holt, 2007; Helfat, 1994; Nelson & Winter, 1982; Nelson, 1961;1991;1995). R&D represents in this regard a measure of institutionalized routine based search where selectively-retained knowledge and experience is important (Chen &Miller, 2007; Greve, 2003; Gavetti & Levinthal, 2000; Nelson & Winter, 1982). The concepts "institutionalized search" and "deliberate search" are used in this paper to capture such routine based problem-solving activity.

Although, R&D lies at the heart of an evolutionary theory of business firm development, strategy and innovation (Helfat, 1994; Nelson, 1995; Winter, 1984), prior empirical research has been largely unable to analyze how different kinds of R&D activities enhance the organizational capacity to innovate in a diverse way. In this paper we take a closer look at the role of internal – and external – R&D for the organizational ability to develop product, process, organizational and market innovations.

According to behavioural and evolutionary theories of the firm, organizations have heterogeneous perceptions (Cyert & March, 1963; Nelson & Winter, 1982). Heterogeneous perceptions constitute another source of inter-firm differences in search capabilities. Cognitions are to a substantial extent unique to firms and their managers. Prior empirical research has to a large extent neglected the role of organizational and managerial cognitions in the innovation process. Recent theoretical research has on the other hand stressed that organizational perceptions constitute an important source of organizational search activity that

enables change at the firm level (Gavetti, 2005; Gavetti & Levinthal, 2004; Gavetti & Rivkin, 2007; Nelson, 2007).

In order to follow up this theoretical research in an empirical manner we will take a closer look at whether perception of problems initiate search activity and enhance the organizational ability to innovate. Managerial perceptions of problems are also linked to "problemistic search" for the simple reason that such activities occur as a response to an organizational problem (Greve, 2003). In order to highlight that such problems are perceived by the managers in our study – and that the problems perceived are context specific and situational – we use the terms "cognitive" and "situational" search to denote search efforts triggered by managerial cognitions (Gavetti & Levinthal, 2000; Chen & Miller, 2007). This type of search activity highlights the role of managerial action and cognition in explaining endogenous organizational change and transformation, an issue which is currently underdeveloped in evolutionary theory (Chen & Miller, 2007; Gavetti & Rivkin, 2007; Gavetti & Levinthal, 2000).

Drawing on evolutionary and behavioural theories of the firm we argue that organizational search based on R&D is close to deliberate problem solving efforts based on retained knowledge and experience. Innovation search triggered by perceptions draws in comparison less on retained knowledge in the search for new variety, technology and innovation. These search efforts are oriented towards solving situational problems as they arise. Such search efforts are measures of situated and forward looking search (Gavetti & Levinthal, 2000; Greve, 2003; Chen & Miller, 2007). Although both types of search processes are important they might be related to different types of outcomes from the innovation process. Hence, heterogeneity in search activity among organisations can be related to a variety of outcomes

from innovation search processes. Empirical analysis of this issue is lagging behind theoretical research in evolutionary economics – and is the main contribution from this paper to the literature.

The research in this paper is based on a novel survey where detailed information about R&D spending, the problems managers perceive in the innovation process, and the types of innovations developed, has been collected from a representative sample of firms from the Norwegian enterprise population. We use this database in order to shed new empirical light on firm heterogeneity in the innovation search process and relate this observed variety to different kinds of innovation outcomes (product, process, organizational and market innovation).

This paper is organized as follows: In the next section we discuss theoretical research related to how and why firms are believed to differ in their approach to innovation. We discuss features of our Norwegian case in section 3. The methodology, data and variables used in the analysis are discussed in section 4. The empirical analysis is conducted in section 5, which is accompanied by a discussion of the empirical results. We draw some conclusions and implications for further research in section 6.

2. Search and innovation

Joseph Schumpeter was one of the first to provide an analysis of the importance of innovation for economic change. He devised a "model" where endogenous technological change is an outcome of investments made by business firms to compete and beat their rivals (Nelson, 1995). According to this view, economic growth occurs through a process of creative destruction where the old industrial structure – its product, its process, or its organization – is

continually changed by innovation (Link, 1980). This theoretical insight has influenced researchers to study the sources and impacts of innovation in the economy (see Fagerberg et al, 2005 for a survey).

Inspired by Schumpeter's work, evolutionary theorists have increasingly highlighted qualitative differences between firms engaged in innovative activity as a major source of innovation and economic progress (Nelson, 1991; Nelson, 1995). The ability to develop and introduce new innovations - or "new combinations" as Schumpeter called it - in the economy is a major source of economic change in evolutionary theoretical frameworks (Fagerberg, 2005; Verspagen, 2005). Evolutionary theory is consistent with a large body of empirical work that has documented the existence of considerable and persistent intra-industry inter-firm differences in profitability and growth rates (Nelson, 1995). The overall evolutionary-theoretical story is thus one in which firms pursue different approaches to innovation, build unique capabilities, and hence develop different kinds of innovations.

Empirical analysis of these issues is lacking however. Contrary to what one might expect, empirical research lags behind theoretical research in evolutionary economics. Recent theoretical advances in evolutionary economics have a loose empirical foundation (Fagerberg (2003). This is an obvious shortcoming in a discipline where appreciative theorizing based upon empirical studies has been a defining feature (see Nelson & Winter, 1982; Nelson, 1995; Fagerberg, 2003; Fagerberg & Verspagen, 2002). A main aim in this paper is to provide an empirical connection back to evolutionary theory where processes associated with the theoretical core in evolutionary economics (e.g. firm heterogeneity and the creation of variety) are analyzed empirically.

A key undertaking in this paper is to empirically explore the diverse ways in which firms search for new innovations and to analyze whether this observed variety is related to different outcomes from innovation search processes. Innovation is in this context a process that starts with a desired end result that a firm – through search activity – aims to achieve (Nightingale, 1998). Desired end results usually have a flip side: A problem that needs to be solved. In this paper we take a closer look at the cognitive and institutionalized search strategies firms initiate in order to innovate. In order to take a closer look at this issue we will start with the deliberate problem solving efforts firms undertake in the innovation process. We start by taking a closer look at the organizational search routine (Nelson & Winter, 1982; Cyert & March, 1963; March, 1991) in the context of industrial R&D.

2.1 Deliberate search and industrial R&D

Nelson & Winter (1982) have proposed that organizational search routines and processes are a main driving force behind innovation at the firm level. Search processes are the deliberate problem-solving activities firms undertake within the context of industrial innovation (Nelson & Winter, 1982; Cyert & March, 1963). In this theoretical framework, organizations learn by storing knowledge in routines that guide behaviour (Levitt & March, 1988).

Research on organizational routines is unfortunately haunted by conceptual ambiguity when it comes to how routines should be defined and interpreted in empirical research (Becker, 2005; Becker et al 2005; Becker, 2004). Although the empirical measurement of organizational routines is a "hard nut to crack", it is a central issue in evolutionary studies of firm behaviour. In this paper we take a closer look at firms' search routines and the learning activities undertaken to find solutions to problems, e.g., .the deliberate processes firms undertake in

order to discover better ways of doing things (Nelson, 1995). How can these deliberate search processes be measured in empirical work?

We simply adopt Nelson's (1995) own answer to basically the same question: "Winter and I have found it convenient to call such search R&D (p.69)". This is essentially a follow-up of an earlier paper by Nelson (1961) where he argues that R&D represents the institutionalization of inventive activities at the firm level. Hence, we will conduct an analysis of R&D activities at the firm level in order to shed empirical light over the deliberate problem-solving activities firms execute in the innovation search process. We thus view R&D activity as an empirical manifestation of the organizational ability to execute deliberate learning and search activities for new technologies and knowledge (Nelson & Winter, 1982; Carroll & Hannan, 2000). Such search activity tends to build on retained knowledge and expertise, as discussed below.

Firms tend to persist in the amount of efforts they devote to different kinds of R&D activities (Helfat, 1994). Persistence of R&D arises due to the path-dependent character of the innovation process where firms search for new technologies in the neighbourhood of current practice and competence (Nelson & Winter, 1982). Experience with a set of organizational routines will enhance the competence of the firm. This will in turn spark off a search process where a main aim is to refine existing technology and to exploit prior knowledge investments and innovations (Cyert & March, 1963; Nelson & Winter, 1982; Stuart & Podolny, 1996; see Laursen, 2008 for a nice review). Routines are as such history-dependent and based upon interpretations of the past (Levitt & March, 1988). Information and knowledge gained from learning are such encoded in routines that are executed when needed (Aldrich, 1999). Hence,

evolutionary processes, such as organizational search behaviour based on R&D, are characterized by strong regularities or "persistence" (Fagerberg, 2003; Dosi, 1988).

R&D is not a homogenous indicator of search however, as it consists of both internal and external R&D. External R&D measures in this regard firms' use of external information and technology in the innovation process, while internal R&D captures knowledge generation and learning within the boundaries of the firm. Although external and internal R&D constitutes distinct search pathways to innovation – they are related in the sense that both constitute a key aspect firms' absorptive capacity (Cohen & Levinthal, 1989; 1990). Empirical research has however largely been unable to analyse the importance of both internal and external R&D to innovation in applied work, something this paper addresses.

Both internal and external R&D is however a measure of institutionalized routine based search where selectively-retained knowledge and experience is important (Chen &Miller, 2007; Greve, 2003; Gavetti & Levinthal, 2000; Nelson & Winter, 1982). The concepts "institutionalized search" and "deliberate search" are used in this paper to capture routine based problem-solving activity. This type of search has also been called "experience based" and "backward looking" because it builds on selectively-retained experience and knowledge (Gavetti & Levinthal, 2000). Such search activity thus explains why firms persistently differ from one another in relation to innovation.

Yet another key evolutionary notion is the theoretical idea that firms pursue different approaches to innovation and that they are able to change their knowledge base in relation to the perception of problems (Cyert & March, 1963; Nelson & Winter, 1982; Nelson, 1991; 1995; Dosi et al; 1997; Dosi & Marengo, 2007). Qualitative differences between firms are as

such more than just differences in persistent R&D efforts across firms. Apart from R&D, firms also differ in terms of how they "think" and "perceive" the world (Fagerberg, 2003; Dosi & Marengo, 2007). How is this related to innovation?

In order to provide an answer let us go back to Schumpeter's (1934) treatment of the entrepreneur. The idea that the organizational capacity to innovate are unevenly distributed in the firm population is essentially Nelson & Winter's (1982) interpretation of Schumpeter, where Schumpeter argued that some individuals will choose to become entrepreneurs due to differences in talents and psychological attributes (Fagerberg, 2003). Hence, an important source of firm heterogeneity is related to differences in "psychological attributes" across firms, e.g. differences in how organizations think and perceive the world (Fagerberg, 2003).

Organizational and managerial cognitions and perceptions have recently (re)emerged as an important subject matter in evolutionary-theoretical research on strategy. "Cognitions and perceptions" in relation to managerial action have in this regard been put forth as an explanation for how firms are able to "break away" from retained knowledge and technology in order to change their knowledge base and initiate more radical search strategies in the innovation process. Gavetti & Levinthal (2000) offer a useful distinction in this regard between "forward-looking" search and "backward looking" search. As discussed previously, "backward looking" search represent experimental wisdom that are an outcome of trial and error learning and the selection and retention of prior behaviour. This is close to R&D. "Forward-looking" search is however based upon actors (e.g. firm management) limited and flawed cognitive representations of their environment. Because the agents of search are people within firms, where managers occupy a key role (Henderson, 2004; Burgelman, 1991; 1994), the innovation process is strongly influenced by cognitive phenomena. Innovating

firms are in this context not blind search agents, in the sense that new variety and innovations are created and developed independently of actors' cognitions and perceptions (Fleming, 2001; Gavetti & Levinthal, 2000).

Evolutionary oriented scholars have accordingly started to theorize about the role of cognition in strategy making at the firm level (Gavetti & Rivkin, 2007; Nelson, 2007; Gavetti et al, 2007; Gavetti & Levinthal, 2000; Gavetti, 2005; Argote & Greve, 2007). What this theorizing has come to argue – in relation to search and strategy formulation - is that strategy exists in manager's minds – in their theories about the world and their company's place in it - ***and*** that strategy is embodied in a firm's activities and routines (Gavetti & Rivkin, 2007). What emerges from this discussion is that managerial cognitions are one important source of search behaviour, in addition to R&D based search. In line with an attention based view of the firm we thus argue that firm behaviour is, at least partly, a function of how firms channel and distribute the attention of their managers (Ocasio, 1997). Managerial attention to the problems firms are facing in the innovation process is a core issue in this regard – and a central issue in behavioural theory (Gavetti et al, 2007). How managerial action and perceptions are linked to search behaviour and innovation is discussed in more detail below.

2.2 Search based on perceptions

According to evolutionary-behavioural theory, firms have different cognitions and perceptions (Nelson & Winter, 1982; Nelson, 1991; Fagerberg, 2003). Differences in perception and cognition arise because firms and their managers are boundedly rational and lack perfect information (Cyert & March, 1963; Nelson & Winter, 1982; Fagerberg, 2003). The development of new technologies is as such an outcome of learning processes where firms search for new routines in a limited-rational way (Nelson, 1995; Kline & Rosenberg,

1986; Dosi et al 1997). Hence, how firms think and perceive the world matters (Fagerberg, 2003). This discussion suggests that organizations enact their own environment through how they perceive the world and initiate strategies and so on based upon these cognitions (Weick, 1979; Levinthal & March, 1993; Hodgkinson, 1997).

In the behavioural theory of the firm, organizations initiate search efforts when their performance falls below an aspiration level that is socially or historically constructed (Cyert & March, 1963; Greve, 2003). Empirical research in relation to performance-feedback theory (Greve, 2003), that draws heavily on the behavioural theory of the firm (Cyert & March, 1963), has shown that search behaviour is initiated when organizational performance falls below an aspiration level. This kind of search activity is positively related to R&D, innovation and investment behaviour at the firm level (Greve, 2003ab). Hence, *perception* of performance and problems is a key issue in relation to organizational search in behavioural theory. Research on performance feedback theory has on the other hand mainly used objective financial measures in order to construct proxies for performance relative to an aspiration level. How the perception of other problems impact on search activity in this regard has not been analyzed empirically using large scale databases.

What the above discussions clearly suggest is that perception of problems is linked to search behaviour. Perception of possible problems is in this context a key aspect of managerial and firm performance insofar as learning is initiated to overcome challenges (Levitt & March, 1988). Perception of problems can as such trigger action, learning and search activity. Because organizations change in response to perceived problems (Amburgey et al, 1993), perception of problems can be related to innovation.

The focus on cognitive search in this paper also helps to develop an underdeveloped – but core - issue in evolutionary theory about the factors that influence endogenous organizational change, transformation and radical search (Chen & Miller, 2007; Laursen, 2008). According to the "classical" evolutionary-theoretical view, firm behaviour and strategy formulation are characterised by inertia and strong past-dependencies (Nelson & Winter, 1982; Nelson, 1995; Dosi, 1982), an assumption that is increasingly being challenged (Gavetti, 2005). Cognitive and situational search is in this regard a theoretical channel that has the premise to explain how and why firms are able change and initiate radical search pats to innovation (Gavetti & Rivkin, 2007; Gavetti & Levinthal, 2000).

Although firm and managerial cognitions differ along a wide array of dimensions, we are in this paper primarily interested in differences in cognitions as they relate to innovation and the search for new technology and knowledge. In this context we are especially interested in the perceived problems firms face in the innovation process. This is because the relationship between perception of problems in the innovation process and subsequent innovative efforts has been put forth as a key issue by seminal theoretical contributions within innovation studies. According to Kline & Rosenberg (1986), perception of "rising development costs", "large financial risks", "technological uncertainty", "regulatory constraints" and "lack of markets", pose serious threats to the organizational capacity and willingness to initiate innovation processes and to innovate.

Although the Kline & Rosenberg (1986) model has been highly influential (Fagerberg, 2005), their concerns should be tested empirically. Are organizational search processes influenced in a negative way by Kline & Rosenberg's (1986) concerns? Or is a more "open" approach

relevant where "cognitions" and perception of problems generate new questions and search for new knowledge in order to overcome challenges (Malerba, 2005)?

At a deeper theoretical level our discussion of firms "cognitive abilities" overlaps with the sources of firm heterogeneity and the characteristics of organizational learning processes (Dosi et al, 1997; Dosi & Marengo, 2007). Although the theoretical idea that managerial perception of problems trigger action and search activity at the firm level is well established, we know little about the actual influence that different types of managerial cognitions have in this regard. We thus extent research on "performance feedback theory" and related theoretical insights to a new empirical terrain: Whether managerial perceptions of non-financial obstacles also influence innovation search.

Due to the absence of precise theoretical analysis and lack of empirical research on this issue we have chosen to take an explorative approach to the subject matter. We have not developed concrete expectations or hypothesis to be tested, apart from the overall theoretical idea that perception of problems is related to search and (different types of) innovative activity. A central objective in this paper is to conduct an empirical analysis of the rather simple argument in evolutionary and behavioural theory that perception of problems initiate search for new technology, knowledge and innovation. Consistent with the explorative nature of the paper we will study how a range of different organizational perceptions influence innovative activity at the firm level.

2.3 Summing up

We have in this paper argued that organizational search processes is an important source of firm level heterogeneity in evolutionary and behavioural theory. Organizational search can on

the one hand be based on retained knowledge and experience. R&D is an empirical manifestation of such search activity and can be split into sub-categories such as internal and external R&D. Search activity can on the other hand also be triggered by managerial perceptions and cognitions. Such search activity relies far less on selectively-retained knowledge and experience but far more on forward looking problem-solving triggered by perception of "situational" problems. Perceptions and cognitions can also be split into different sub-categories.

Hence, there exist a range of search channels and strategies that firms will influence the "paths" firms follow in the innovation process. How these search activities are related to the organisational capacity to develop different types of innovations is a rather unexplored empirical terrain. It is important to shed empirical light over such issues in order to advance the evolutionary- theoretical understanding of firm behaviour (Fagerberg, 2003). Although some recent simulation and qualitative studies have been conducted (Gavetti & Levinthal, 2000; Gavetti, 2007; Hugo & Garnsey, 2004) there has been little empirical research using large scale databases. Below we will discuss in more detail how R&D activity and managerial perceptions of problems might influence innovation activity at the firm level in relation to some descriptive statistics.

3. Exploring search activities: descriptive statistics

We argued in the above section that both R&D and perception of problems are empirical manifestations of search activity – or will trigger such activity. In this section we briefly present some descriptive statistics on the problems managers in our surveyed firms perceive to be important in the innovation process, the use of R&D by industrial enterprises, and the different types of innovations firms have developed. The statistics presented in this section

refer to the 2002-2004 time period and are broadly representative for the enterprise population in Norway with 10 or more employees. The survey data is discussed in more detail below, in section 4.

In Table 1 below we have explored the extent to which Norwegian firms are engaged in R&D. We do so for both internal R&D and external R&D. As we can see in Table 1, about 33 % of the firms in our sample claimed to have been engaged in internal R&D in the time period 2002-2004. Almost 21 % of the firms have been engaged in external R&D in the same time period. Hence, internal R&D is the preferred deliberate search activity when Norwegian firms aim to develop new technology and knowledge.

[Table 1 about here]

In the above section we argued that internal and external R&D constitute distinct – but related - separate search pathways to innovation. As we can see in Table 2, some firms only use internal R&D - while some firms only use external R&D - in the deliberate search for new innovations. But the share of firms using only external R&D is low. Firms using external R&D also tend to engage in internal R&D. This is in line with the literature on absorptive capacity (Cohen & Levinthal, 1989; 1990) where it is more or less argued that internal R&D is a prerequisite for being able to draw on external knowledge in the innovation process. The ability to draw on and integrate external technology with internal knowledge is in this regard considered to be a source of competitive advantage and enhanced innovative performance (Chesbrough, 2003; Chesbrough et al, 2006; Laursen & Salter, 2006).

[Table 2 about here]

It is a central argument in this paper that organizational perceptions are an important source of firm heterogeneity in relation to innovation at the firm level. In Table 3 we have provided the percentage share of firms in our survey who perceive the displayed factors to be an "important" obstacle to innovation. The scale goes from 0 = not relevant, to 3 = high importance. Because some managers did not answer the questions about innovation obstacles in the survey we lack answers from around 400 firms.

[Table 3 about here]

We discussed previously that perceived barriers to innovation can constitute an important source of search activity. Perception of "deep" problems can in such a theoretical framework trigger organizational search responses (Cyert & March, 1963; Nelson & Winter, 1982). In Table 3 we see that the most "highly cited" innovation obstacles are "innovation costs" and "lack of finance". "Lack of finance" and "high innovation costs" are usually put forth as negative determinants of innovation in the literature (Hall, 2002; Kline & Rosenberg, 1986). It remains to see whether managers in firms with such perceptions innovate. Could it be the case that detection of possible "cost" and "financing" issues trigger search for solutions to overcome such problems? If the innovation process starts with a desired end result (Nightingale, 1998) – or "turned around" – starts with a desire to solve a problem, the perception of problems could be related to innovations that solve the perceived problem.

It is also interesting to note that "uncertain demand" and "market domination by established incumbents" are perceived to be among the most important barriers to innovation by the

responding firm managers in our survey. Understanding the role of demand in innovation processes has been highlighted as important in recent reviews of the literature (Castellacci et al, 2005; Pianta, 2005; Mowery & Rosenberg, 1979), as well as understanding the role of innovation in relation to industry entry barriers (Geroski, 1995; Audretsch, 2001). Will firms and managers with the above-mentioned perceptions try to innovate in order to create new demand or innovate in order to destroy the existing industrial structure and market domination by established incumbents? We will touch upon these issues in section 5 where we will analyze whether firms with such perceptions are more or less inclined to innovate.

According to the firm managers in our survey it is not difficult to find an "innovation cooperation partner" or, in other words, lack of such a partner does at least not seem to constitute a barrier to innovation for the overall majority of firms. How does such a perception impact on firm level innovation processes? Access to innovation networks is generally believed to be an important determinant of innovation (Powell & Grodal, 2005). Will firms who find it hard to identify an innovation cooperation partner be less inclined to innovate?

It is also interesting to note that "lack of technological information" and "lack of market knowledge" are not highly cited barriers to innovation. Do firms that perceive these factors to be of low importance innovate more frequently, as suggested by for instance Kline & Rosenberg (1986)? If so, the Norwegian enterprise population should be highly innovative. Or is it on the other hand more likely that innovative firms simply perceive more problems (Baldwin & Lin, 2002; Galia & Legros, 2004; Mohnen & Röller, 2005)? If so, the level of innovation should be rather low in Norway.

In Table 4 we have analyzed the prevalence of product, process, organizational and market innovation in the Norwegian enterprise sector. According to the statistics in table 3, almost 30 % of the firms in our sample developed a product innovation, while about 24 % developed a process innovation in the time period 2002-2004. Product and process innovation have been the usual indicators of innovative activity in the literature (see Smith, 2005 for a review). It is therefore interesting to explore the prevalence of market and organizational innovation in the enterprise population. According to table 3, about 28 % of the firms had undertaken an organizational innovation, while almost 26 % of the firms had developed a market innovation in the same time period. Organizational and market innovations are as such equally prevalent among firms in the Norwegian enterprise population as product and process innovation.

[Table 4 about here]

4. Method, data and variables

In the section below we discuss the methodology, data and variables used in the analysis. The main aim is to analyze how R&D and perceptions are related to innovation at the firm level. Because binary indicators of innovation are used as dependent variables we will use logistic regression in the analysis. Logistic regression has been especially designed to handle binary dependent variables where the presence or absence of an outcome is analyzed (innovation or not innovation).

4.1 Data

The research in this paper builds upon a novel R&D and innovation survey that was distributed to a representative sample of Norwegian enterprises with 10 employees or more in 2006. The majority of questions refer to the time period 2002-2004, but some also refer to

2004. Every firm with 50 or more employees was included in the sampling frame. The survey is the Norwegian implementation of the forth Community Innovation Survey (CIS) that builds on the survey methodology described in the OSLO manual (OECD, 2005). Further, Statistics Norway has undertaken a lot of efforts to ensure that the data quality is good, efforts which can not be matched by single researchers or consultancy firms. A description of these efforts is available in a report from Statistics Norway (Salte, 2007).

In this paper we use survey data where managers are asked a range of questions about R&D activity, innovation, and the problems managers perceive in the innovation process. One methodological problem with these kinds of survey data is subjectivity (Smith, 2005). Subjectivity can create some problems, most notably for survey questions that are supposed to be "objective", like R&D and innovation. In the end it is up to the respondent to decide whether a product is a new innovation, and whether some activity falls under the R&D rubric. R&D and innovation are important firm level activities. In our view managers should be capable of providing answers to simple questions about R&D and innovation without too much error. Firm managers are usually highly educated people.

The methodological approach we follow in this paper was actually first initiated by Mansfield in his novel efforts to collect data on R&D at the firm level (Scherer, 2005). The main point in this approach is simply that:" if you want to know something, ask the people who know" (Scherer, 2005, p 5). Subjectivity can in this regard also be an advantage, most notably for evolutionary oriented scholars who argue that managers have different cognitions and perceptions. The survey data we have access to ask managers about whether they perceive different innovation obstacles to be a problem in the innovation process. In this particular case, it is subjectivity that we want.

Every firm in the sample frame was asked to answer the questions about R&D activity, also non-innovative firms. This is a special feature of the Norwegian implementation of the CIS survey. All the questions used in the analysis have as such been posed to both innovators and non-innovators. The survey was returned by 4655 firms which constitutes a response rate of 95 %. The high response rate needs to be seen in relation to the fact that it was compulsory for firms to return the questionnaire. It can always be argued that the compulsory nature of the survey can lead to bad data quality. We do not think this is the case in our Norwegian context. R&D surveys have been conducted since the 1970's by Statistics Norway. Statistics Norway is further considered to be an impartial and well recognized public organization.

Due to some missing values on the independent variables used in the analysis, most notable in association with the "perception variables", the sample size drops with around 400 firms. There are no missing values on our R&D or innovation variables however. In total, the problem with item non-response and missing observations represents less than 10 % of the total sample. This should not constitute a major source of selection bias.

4.2 Variables

We have 4 dependent variables in the analysis; **product innovation, process innovation, organizational innovation and market innovation.** **Product innovation** is measured through the firm managers' response to the following questions: "During the period 2002-2004, did your enterprise introduce onto the market any new or significantly improved products (goods or services) for your enterprise?" Managers could respond to a 3 point scale where "0 = no", "1 = yes, goods" and "2 =yes, services". Because it is not clear in the survey whether managers could tick both "1" and "2", we recoded this variable so that firms with a 1" and / or "2" answerer are counted as product innovators (1=yes, 0 = no).

Process innovation is measured through the managers' response to the following 3 questions in the survey: During the period 2002-2004, did your enterprise introduce any new or significantly improved "production processes", "methods for distribution or supply" and "support systems". Firms answering yes to one or more of these questions are counted as a process innovator (1 = yes, 0 = no). **Organizational innovation** is measured through the managers' response to the following three questions in the survey: Please tick whether your enterprise introduced any of the following changes in the time period 2002-2004: "New or significantly improved knowledge support systems", "large changes in work organization, inside the enterprise", and "changes in the relationship to other organizations, such as alliances, partnerships, etc". A firm answering yes to one or more of these questions is counted as an organizational innovator (1 = yes, 0 = no).

Market innovation is measured through the managers' response to the following three questions in the survey: During the period 2002-2004, did your enterprise introduce any of the following market innovations "substantial change in product or service design", "new or substantially altered sales or distributions methods", "sales efforts towards new customers or market segments". A firm answering yes to one or more of these questions is counted as a market innovator (1 = yes, 0 = no).

Compared to prior research we analyse whether the "determinants of innovation" differ according to the sub-categories of innovation described above (product, process, organizational and market innovation). Such an approach has been recommended in a recent review (Edquist, 2005). It should also be noted in this context that Reichstein & Salter (2006) argue that process innovation has received too little attention compared to product innovation in innovation studies. Empirical research on organizational and market innovation is also

lacking in the literature. This is mainly because survey data on these innovations first started to emerge with the forth version of the CIS 4 survey. Both organizational and market innovation are however central to a Schumpeterian and evolutionary understanding of innovation (Drejer, 2004).

Managers were also asked to state whether their firm had been engaged in **internal R&D**, and **external R&D**, in the 2002-2004 time period (1 = yes, 0 = no). We pose both **internal R&D** and **external R&D** as important determinants of innovation. Most empirical research has in comparison treated R&D as a homogenous indicator. Although this has been criticised in the literature (Griliches, 1986; Link, 1982), few papers have in fact been able to offer a breakdown of R&D into different categories. It is important to offer such a breakdown because internal and external R&D constitutes distinct – but related - search paths to innovation (Cohen & Levinthal, 1989; 1990; Chesbrough, 2003; Chesbrough et al, 2006). R&D has also been used as a measure of the technological opportunities firms face (Klevorick et al, 1995).

A predefined set of survey questions referring to innovation obstacles as perceived by the responding firm managers are also available to us. These questions were directed to the firm management and mainly capture the perceptive abilities or cognitions of the CEO or R&D manager to whom the survey is directed. Managers are however considered to be an important evolutionary agent and a driving force behind firm behaviour (Burgelman, 1991;1994; Gavetti & Levinthal, 2000; 2007; Gavetti & Rivkin, 2007; see Henderson, 2004 for an elaborated discussion).

The following general question was asked: "If your enterprise experienced any hampering factors during the period 2002-2004, please grade the importance of the relevant factors". The responding manager could tick the following hampering factors from 0 = not relevant to 3 = high degree of importance: "Innovation costs too high", "lack of finance within the enterprise", "lack of appropriate sources of finance from outside the enterprise", "lack of qualified personnel", "lack of information on technology", "lack of information on markets", "difficult to find cooperation partners for innovation", "market dominated by established incumbents, and "uncertain demand after new goods and services". With these questions we want to explore the relationship between perception and innovation. Although we do not have the usual data on performance relative to an aspiration level, in many cases measured by *objective* performance measures (Greve, 2003), we nevertheless have interesting data on managerial *perception* of problems. This latter aspect is also important to evolutionary-behavioural theories about firm behaviour (Gavetti, 2004; Gavetti & Levinthal, 2000; Gavetti & Rivkin, 2007).

It is important to highlight that we control for R&D when assessing the relationship between managerial perception and innovation. The reason is that perceived innovation obstacles consist of at least two dimensions: First of all a "real obstacle", and secondly an "experience" obstacle. The latter is a function of the opportunity set firms face[2]. In accordance with the theoretical perspective discussed in section 2 we are in this paper mainly interested in understanding how managerial perceptions of "real obstacles" influence innovation. In order to ensure that this is what we actually do, we control for both internal and external R&D in the analysis. According to prior studies, R&D doing firms perceive more innovation obstacles compared to non-R&D doing firms. The reason is that innovation is as learning process where

[2] I would like to thank Keld Laursen for this explicit comment

R&D doing firms face more technological opportunities but also more obstacles (Baldwin & Lin, 2002; Galia & Legros, 2004; Mohnen & Röller, 2005). By controlling for R&D in the analysis, the influence of the "perception variables" on innovation will not be due to "technological opportunities" (which are captured by the two R&D variables as discussed above).

We have measured **firm size** by running a principal components factor analysis where standardized indicators of "number of employees" and "turnover", both measured in 2004. One factor was extracted. The details are reported in the appendix. We thus provide a latent measure of firm size because it is not clear-cut whether "sales" or "number of employees" is the best measure to use in this regard. Although there is a large (and old) debate about the role of firm size for innovation in innovation studies (see Cohen, 1995; Cohen & Levin, 1989 for reviews) there has been hardly any debate about what firm size measure to use in empirical research. We also control for **group membership** in the analysis. The variable **group** is a dummy and indicates whether a firm is a part of a group or not (1 = yes). The reason for including group as a control variable is that firms with group membership are likely to have access to superior financial resources from a corporate parent.

It is a central theoretical finding in the literature on the economics of innovation that the nature of knowledge underlying industrial innovation, technological opportunities, and appropriability conditions differs across industrial sectors (Levin et al 1985; Levin et al, 1987). In order to take this into account we include industrial sector industry dummies in the analysis (not reported).

A methodological issue that we need to briefly discuss is the "time overlap" between the dependent and some of the independent variables in the analysis: the "innovation", "R&D and "perceptions" variables are all measured in the time period 2002-2004. In order to estimate our model using logistic regression we assume a recursive relationship between the dependent and the independent variables. This is a critical assumption in our study. In our view this assumption can be justified because both "R&D" and "perceptions" are "process" variables whereas "innovation" is an outcome (Verspagen, 2004). Assuming such a recursive relationship is "normal" in research using CIS data. Prominent examples with a similar assumption (either implicit or explicit) are Laursen & Salter (2006) and Reichstein & Salter (2006).

5. Analysis

In this section we analyse the determinants of innovation with a particular emphasis on how different types of search activities influence innovative activity at the firm level. In order to do so we estimate equation 1 below using logistic regression:

1) $$Y_1 = B_0 + B_1X_1 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 + B_6X_6 + B_7X_7 + B_8X_8 + B_9X_9 + B_{10}X_{10} + B_{11}X_{11} + B_{12}X_{12} + B_{13}X_{13} + E_1$$

Where Y_1 is one of our 4 binary innovation indicators, for example "product innovation", X_1 is "external R&D", X_2 is "internal R&D", X_3 is "innovation costs", X_4 is "finance within the enterprise", X_5 is "finance from outside sources", X_6 is "qualified personnel", X_7 is "technological information", X_8 is "market information", X_9 is "cooperation partner", X_{10} is "market domination by incumbents", X_{11} is "uncertain demand", X_{12} is "firm size", X_{13} is "group" and E_1 is the error term. The actual results are reported in table 5 below.

[Table 5 about here]

In table 5 we can see that both external R&D and internal R&D are positive predictors of product, process, organizational, and market innovation. This set of findings adds to recent papers where the importance of R&D for innovation has been explored (Mairesse & Mohnen, 2005; Crepon et al, 1998). In comparison to prior empirical research our findings demonstrate that both internal and external R&D have a positive influence on the organizational capacity to innovate.

Our results show in addition that internal and external R&D are positive determinants of the organizational ability to innovate in a diverse way. We have found that using retained knowledge and experience in the innovation search process enhance the organizational capacity to innovate with regard to product, process, organizational and market innovation. Hence, both internal and external R&D constitute search pathways to innovation at the firm level. R&D, with a breakdown by different sub-categories, is as such a main source of firm heterogeneity in relation to industrial innovation. This is in line with evolutionary theory where R&D represents "the institutionalization" of inventive activities at the firm level (Nelson, 1961), and consequently measure the deliberate search routines firms execute in the innovation process (Nelson & Winter, 1982).

Consistent with prior empirical research we find that using selectively-retained knowledge and experience in the search process yields as strong and positive influence on the organizational capacity to innovate (Chen & Miller, 2007). This empirical finding illustrates the evolutionary-theoretical argument that firms tend to persistently differ in relation to innovation due to the evolutionary processes of selection and retention (Nelson & Winter,

1982; Dosi, 1982). Persistence is however not the only relevant aspect of the organizational capacity to innovate. In the section below we discuss findings showing that managerial cognitions are another source of search activity.

Contrary to what one might expect at first sight we find that "lack of technological information" is a positive determinant of innovation. When firms perceive this obstacle to be a hampering factor they are significantly more inclined to develop both process and product innovations. Although lack of information about technology can pose a serious obstacle to innovation, a responding firm level strategy is to search for such knowledge in order to innovate. Hence, the results suggest that organizational perceptions trigger search activities that are related to the organizational capacity to innovate. Perception of technological obstacles thus leads to creative firm level search processes that are related to innovation (Hugo & Garnesey, 2004).

We also find that "lack of market information" and "uncertain demand" are positive determinants of the organizational ability to develop product and market innovations. When organizations perceive such hampering factors to represent problems of high importance they tend to initiate search activities for new innovations in order to capture new markets and secure new product turnover. Securing profits through product innovation and capturing new markets is a central strategic firm level response to competition in strategic management theory (Teece, 1986; 2007; Teece et al, 1996). Hence, managers perceiving "lack of market information" and "uncertain demand" to represent problems of high importance seek to remedy this situation by initiating search activities that are positively related to the organizational capacity to innovate. There is as such a nice link between managerial perceptions of problems and the strategic search responses undertaken by industrial firms. We

have as such taken one small step forward in our understanding as to how (perception of) demand is tied to innovation processes at the firm level, something that has been highlighted as a key research topic in innovation studies (Castellacci et al, 2005; Pianta, 2005; Mowery & Rosenberg, 1979).

We also find that "lack of funding" from within the enterprise is a positive determinant of organizational innovation. The importance of "funding issues" as a negative determinant of innovation has mainly been explored with reference to public provision of R&D in relation to market failure arguments (Hall, 2002). Our findings stand out in slight contrast to this, as we find that perception of funding problems is a positive determinant of organizational innovation. We thus find that firms aim to overcome innovation funding problems by enhancing knowledge flows inside the company, conducting large scale work-reorganizations, and by getting an external partner or alliance (the three indicators of organizational innovation). Access to innovation networks and external co - operation partners are generally believed to be an important determinant of innovation (Powell & Grodal, 2005). It is interesting to note in this context that industrial enterprises whose management perceive lack of "cooperation partner for innovation" to represent a hampering factor have a significantly lower propensity to develop market innovations. Hence, having access to innovation cooperation partners are an important part of the organizational capability to enter or create new markets.

"Lack of funding" is tied to the perception of "innovation costs" as a hampering factor. When "high innovation costs" represents a perceived problem of higher importance, firms are more inclined to develop product, process and market innovations. Hence, when managers perceive this innovation obstacle to be a problem, their firms are significantly more inclined to develop

a diverse range of innovations in response. Based upon what we know about the nature of innovation, this makes sense: While product innovations capture new markets together with market innovations, process innovations reduce costs (Fagerberg, 2005; Pianta, 2005; Drejer, 2004). Firms and managers who perceive innovation costs to represent an impediment to innovation thus bundle different types of innovations together in order to secure new product turnover, capture new markets, and reduce production costs.

It is further interesting to note that firms perceiving "lack of qualified personnel" to constitute an innovation obstacle are significantly more inclined to develop both process and organizational innovation. Again, this makes sense based upon what we know about the character of innovation: Process innovation reduce the demand for labour in the organization while organizational innovations reorganize work practices within the firm (Pianta, 2005; Verspagen, 2004; Drejer, 2004). There is as such a nice "micro-link" at the firm level between managerial perception of problems and the types of innovations their firms develop in order to solve the perceived problems.

Understanding the role of innovation in relation to industry entry barriers has also been highlighted as an important issue in innovation studies by reviews of the literature (Geroski, 1995; Audretsch, 2001). A central question in this regard has been whether firms are less inclined to innovate and are deterred from market entry in industries dominated by large incumbents. According to the results presented in Table 5 this seems to be a valid perspective as the perception of market dominance is a negative predictor of product innovation. This is arguably due to the presence of industry standards that generally goes together with entrenched market structures and dominance by large incumbents (Klepper, 1997; Utterback, 1996). But firms with such perceptions are not necessarily inert and unable to change in

response to entrenched market structures. Managers who perceive that their market is dominated by established incumbents aim in fact to destroy existing market structures or to create new markets by developing organizational and market innovations in response.

These findings demonstrate that it is important to include other types of innovations apart from process and product innovation in order to better understand how organizational cognitions constitute a source of firm heterogeneity in relation to innovation. Our findings clearly demonstrate that organizational and market innovations are an important part of the process of creative destruction as described by Schumpeter (Drejer, 2004; Schumpeter, 1934). These findings also confirm a series of studies arguing that firms cognitive representation of their industry context yield a strong influence on strategy processes at the firm level (Hodgkinson, 1997). In our study we have extended this line of research to industrial innovation.

What do these results imply for evolutionary and behavioural understandings of firm heterogeneity? Our results imply that both R&D and managerial cognitions of problems constitute different types of search pathways to innovation at the firm level. We have seen that both internal and external R&D enhance the organizational capacity to develop product, process, organizational and market innovations. In contrast to prior empirical research we have documented that both internal and external R&D constitutes distinct search pathways to different types of innovations at the firm level. Using retained knowledge and experience in the innovation search process thus enables firms to innovate, as argued in evolutionary and behavioural theory (Nelson, 1961; Nelson & Winter, 1982; Nelson, 1995; March, 1991). Both internal and external R&D is an important source of persistent firm heterogeneity in relation to innovation.

Our results also suggest that perception of problems trigger organizational search processes, as argued by evolutionary and behavioural theories of the firm (Cyert & March, 1963; Nelson & Winter, 1982). Organizational search efforts based on perceptions of problems are however related to innovation in different ways. Some perceptions, like "innovation costs", are positively related to both product and process innovation. Other perceptions, like "lack of market information", are positive predictors of the organizational capacity to develop a market innovation. Yet other types of managerial cognitions, such as "lack of qualified personnel", are related to the ability to develop an organizational innovation. What emerges from these findings is that managerial and firm cognitions are an important source of firm heterogeneity in relation to innovation. There is as such a nice "micro-link" at the firm level between perception of problems and the types of innovations developed to solve the perceived problems.

This set of findings confirms recent theorizing arguing that cognitions and perceptions in relation to managerial action constitute a source of endogenous organizational change and radical search behaviour (Gavetti & Levinthal, 2000; Gavetti, 2004; Gavetti & Rivkin, 2007), something which as been a underdeveloped issue in evolutionary-behavioural theory. We have in this regard also extended research on "performance feedback" theory to a new empirical terrain, in the sense that we have analyzed whether managerial perception of problems trigger innovation search activity at the firm level.

6. Conclusion

The main objective in this paper has been to analyse firm heterogeneity in relation to innovation at the firm level. In order to provide such an analysis, we have taken a closer look at how industrial firms search for new knowledge, technology and innovation. Organizational search processes are believed to be the main driving force behind innovation at the firm level in evolutionary and behavioural theories of the firm (Nelson & Winter, 1982; Cyert & March, 1963; Argote & Greve, 2007; Laursen, 2008). The empirical understanding of firm heterogeneity and organizational search in relation to innovation in this regard is lacking however (Fagerberg, 2003).

We have focused on two main categories of search in this paper in order to provide an empirical analysis of firm level heterogeneity in this context: Both R&D and managerial perceptions are in our theoretical framework sources of search activity for (different kinds of) innovations. Our results show that (different types of) R&D and managerial perceptions constitute distinct search pathways to a diverse range of innovations at the firm level. Both R&D and perceptions are positively related to the organizational capacity to develop product, process, organizational and market innovations. Hence, such search activities are an important source of firm heterogeneity in relation to innovation at the firm level.

A weakness with our approach is that we have not been able to analyze how firms search over time. "Tracking firms" over time is also a potential solution to the problem that "search" variables and "innovation variables" are measured within the same time period. Connecting different "waves" of the CIS survey can be a solution to this problem. Another shortcoming is that we have only measured the deliberate and retained search efforts firms pursue by R&D. Although R&D is a central variable in evolutionary accounts of firm behaviour (Nelson,

1991;1995; Nelson & Winter, 1982; Helfat, 1994; Chen & Miller, 2007) it would have been informative to include empirical measures of the deliberate but non-technical search routines firms execute in the innovation process. It has not been possible to address this issue in this paper due to the lack of such questions in the CIS survey. Future revisions of the OSLO manual should take this into account.

Appendix

Table A1. Factor analysis using number of employees and turnover as input variables (standardized variables)

Measures of firm size	Factor loadings
Number of employees	0,899
Turnover	0,899
Cumulative % of explained variance	0,81

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Table 1. Engagement in internal and external R&D

	% yes	N
Internal R&D	32,9	4655
External R&D	20,9	4655

Data source: Own calculation based upon the Norwegian CIS 4 survey.

Table 2. Overlap between internal and external R&D

	% yes
Only internal R&D	14,3
Only external R&D	2,3
Both internal and external R&D	18,6
No R&D activity	64,8
N	4655

Data source: Own calculation based upon the Norwegian CIS 4 survey.

Table 3. Percentage of firms answering "not relevant" to "high importance" on innovation obstacles

Innovation obstacle	Not relevant	Little Imp.	Medium Imp.	High Imp.	Sum	N
Innovation costs too high	50,6	16,6	21,9	10,9	100 %	4339
Lack of finance within the enterprise	52,9	21,4	16,4	9,2	100 %	4310
Lack of finance from outside the enterprise	58,8	20	13,5	7,7	100 %	4303
Lack of qualified personnel	55	27,7	13,6	3,7	100 %	4323
Lack of information on technology	54,9	32,6	10,5	2	100 %	4325
Lack of information on markets	54,6	30,2	12,9	2,3	100 %	4326
Lack of cooperation partners for innovation	59,7	27,9	10,3	2,1	100 %	4305
Market dominated by established incumbents	57,7	23,8	13,5	4,9	100 %	4300
Uncertain demand after new goods and services	52,8	21,2	19,5	6,5	100 %	4312

Data source: Own calculation based upon the Norwegian CIS 4 survey.

Table 4. Percent of firms having developed an innovation, distributed by innovation types

Type of innovation	% yes	N
Product innovation	29,7	4655
Process innovation	23,6	4655
Organizational innovation	27,6	4655
Market innovation	25,5	4655

Data source: Own calculation based upon the Norwegian CIS 4 survey.

Table 5. Determinants of innovation

	PRODUCT INNOVATION		PROCESS INNOVATION	
	Beta	OR	Beta	OR
R&D VARIABLES				
External R&D	0,605***	1,83	0,569***	1,77
Internal R&D	2,774***	16,03	1,885***	6,59
INNOVATION OBSTACLES				
High innovation cost	0,297***	1,35	0,305***	1,36
Lack of finance within the enterprise	-0,004	1,00	0,010	1,01
Lack of finance from outside sources	-0,036	0,96	-0,092	0,91
Lack of qualified personnel	0,045	1,05	0,172***	1,19
Lack of technological information	-0,021	0,98	0,199**	1,22
Lack of market information	0,324***	1,38	-0,130	0,88
Lack of co-operation partner for innovation	-0,104	0,90	-0,004	1,00
Market dominated by established incumbents	-0,119*	0,89	-0,087	0,92
Uncertain demand	0,202***	1,22	-0,038	0,96
FIRM FACTORS				
Firm size	0,130**	1,14	0,250***	1,28
Group	0,107	0,90	0,078	1,08
Constant	-2,8	0,061	-2,954	0,052
R^2	0,59		0,37	
N	4165		4165	

*** sig at the 0,01 level, ** sig at the 0,05 level, and * sig at the 0,1 level

Table 5 continued. Determinants of innovation

	ORGANIZATIONAL INNOVATION		MARKET INNOVATION	
	Beta	OR	Beta	OR
R&D VARIABLES				
External R&D	0,569***	1,77	0,347***	1,41
Internal R&D	0,383***	1,47	1,160***	3,19
INNOVATION OBSTACLES				
High innovation cost	0,054	1,06	0,106**	1,11
Lack of finance within the enterprise	0,263***	1,30	0,046	1,05
Lack of finance from outside sources	-0,014	0,99	0,029	1,03
Lack of qualified personnel	0,129**	1,14	0,105	1,11
Lack of technological information	0,137*	1,15	0,076	1,08
Lack of market information	-0,131*	0,88	0,218***	1,24
Lack of co-operation partner for innovation	0,027	1,03	-0,145**	0,87
Market dominated by established incumbents	0,186***	1,20	0,175***	1,19
Uncertain demand	0,017	1,02	0,055	1,06
FIRM FACTORS				
Firm size	0,202***	1,22	0,037	1,04
Group	0,579***	1,78	0,150*	1,16
Constant	-2,05	0,12	-2,4	0,09
R^2	0,2		0,27	
N	4165		4165	

*** sig at the 0,01 level, ** sig at the 0,05 level, and * sig at the 0,1 level