Radical Versus Incremental Open Innovation - Are Service Firms Different?

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Abstract

The shift towards more open and interconnected innovation activities has been a major topic of recent academic and practitioner discussions. Firms have to connect their in-house R&D activities with external partners, such as leading customers or universities, to increase the effectiveness of their innovation activities. Hence, management needs to define search strategies for valuable knowledge in its environment. In this paper we argue conceptually that search strategies have to reflect the heterogeneities of various knowledge sources with regard to the knowledge they can provide and how these sources can be activated. We hypothesize that science-, supply- and market-driven search strategies will contribute differently to innovation success with radically new versus incrementally refined products. What is more, we suggest that innovation in service sectors is fundamentally different in nature which also influences the performance of different search strategies. We test these hypotheses for a sample of more than 5,000 firms from 5 European countries based on a harmonized survey. The results support our major hypotheses and highlight the potentials and shortcomings of different search strategies. Targeted management recommendations are derived based on these results.

Keywords: Open innovation, absorptive capacity, service innovation

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1 Introduction

Research has frequently shown that firm success in technology-driven industries critically depends on the ability to invent and to bring innovative technology on the market (e.g., Katila, 2002; Katila and Ahuja, 2002). In this respect, firms with the ability to create new technological knowledge have been praised for generating and acquiring internal as well as external sources of new knowledge (Rosenkopf and Nerkar, 2001b). However, the process of identifying knowledge to be integrated into the organizational knowledge base requires that firms deliberately search for and reach out to promising sources. Search has been characterized as the fundamental mechanism enabling firms to learn and organizational knowledge to evolve. Besides 'local search', which assumes research and development (R&D) activities to be connected to the firm's previous R&D (Nelson and Winter, 1982), literature has emphasized the importance for firms to move beyond local search and to reconfigure the existing knowledge base (Kogut and Zander, 1992; Teece *et al.*, 1997). In fact, the search strategy, defining direction and priority of boundary-spanning search activities, has been found to substantially impact innovation performance (Katila, 2002; Katila and Ahuja, 2002; Laursen and Salter, 2006).

While literature on the nature and effects of firms' search activities has become abundant, several shortcomings remain. In this paper, we wish to shed new light on the relationship between the search strategy of the firm and the innovation performance. We review major literature on how firms design search strategies to acquire external knowledge. Our goal is to extend the academic discussion along three major dimensions. First, research on the nature of these search strategies has largely focused on the dimensions of breadth and depth (e.g. Laursen and Salter, 2006). We argue that the description of search strategies along their breadth and depth underestimates the degree of heterogeneity among the various knowledge sources they encompass. Instead, we argue that management will choose certain directions (market, science, supply) for the firms' search strategies targeting particular knowledge sources. Second, existing studies, analyzing how firms search, typically link search strategies to very generic and broadly defined innovation outcomes, e.g. counts of patents or new product introductions, sales with new products, etc. We suggest that these targeted search strategies differ with regard to the type of innovation success (incremental vs. radical) they generate. Third, research has mostly concentrated on the manufacturing sector and, more specifically, on high-technology industries. Identifying how firms learn and how the organizational knowledge evolves, however, should not be limited to these industries, particularly given the importance of the service sector for the overall economy. Therefore, we highlight the distinct patterns of innovation in service sectors and the effects they have on the effectiveness of particular search strategies. All three aspects have been largely neglected in the discussion of search strategies (e.g. Katila and Ahuja, 2002; Laursen and Salter, 2006; Rosenkopf and Nerkar, 2001b) which is why they warrant further investigation.

Our research is based on a comprehensive dataset of more than 5,000 manufacturing and services firms from five European countries. The paper is organized in seven sections. The next section details our theoretical framework, providing the reference for our hypothesis development in Section 3. Section 4 describes our empirical methods. Results are presented and discussed in the subsequent two sections. Section 7 concludes with limitations of our study and implications for further research.

2 Theoretical framework

Our theoretical discussion is grounded on the knowledge-based view of the firm (Grant, 1996; Liebeskind, 1996). It is widely accepted that a firm's ability to innovate is tied to the pool of knowledge available within an organization (e.g., Subramaniam and Venkatraman, 2001; Subramaniam and Youndt, 2005). The generation of new knowledge has traditionally been connected to a firm's in-house research and development (R&D) activities. Recent literature, however, points to the advantages of combining internal investments with external resources (e.g., Cassiman and Veugelers, 2006) to benefit from complementarities. In other words, firms have begun to open up their innovation processes for external knowledge. This trend of so-called "Open Innovation" allows firms to access and exploit external knowledge while internal resources are focused on core activities (Chesbrough, 2003). Both supply- and demand-oriented aspects bring firms in a position to acquire knowledge externally. On the one hand, there is an increasing availability of external knowledge, e.g. from universities, customers and specialized suppliers (e.g., von Hippel, 1988; Link and Scott, 2005; Perkmann and Walsh, 2007; van Echtelt *et al.*, 2008). On the other hand, firms are also forced to find new sources for innovation impulses because of increasing competitive pressures, shorter product life cycles as well as technological opportunities beyond the traditional fields (e.g., Calantone *et al.*, 1997; Chatterji, 1996; Kleinschmidt and Cooper, 1988; Ojah and Monplaisir, 2003). Several studies have identified positive performance effects from incorporating external knowledge (e.g. Gemünden *et al.*, 1992; Laursen and Salter, 2006; Love and Roper, 2004).

Firms need to reach out for actors beyond firm boundaries to maximize the benefits from inventions and ideas (Rosenkopf and Nerkar, 2001a). Deliberate search activities of a firm for identifying these knowledge sources can be described as its search strategy providing direction and priorities for external knowledge acquisition. A search strategy is defined as an "organization's problem-solving activities that involve the creation and recombination of technological ideas" (Katila and Ahuja, 2002: 1184). Consequently, investments in problem-solving activities should result in favourable combinations and linkages of users, suppliers and other relevant actors in the innovation system. Laursen and Salter (2006) discuss the concepts of breadth and depth as important factors for a firm's search strategy. Although a broader set of external sources reduces the risk of unexpected developments, it has to be taken into account that a firm is constrained in terms of the capacity to absorb external knowledge (Cohen and Levinthal, 1989, 1990). These limitations include the level of overall attention a firm's management can dedicate to these activities (Ocasio, 1997). A proper search strategy should therefore concentrate on certain external sources as a vast number of information sources would hamper selection and in-depth exploration processes (Koput, 1997). Contrary to search breadth, search depth can be described as the extent to which firms draw deeply from the various external sources for innovation impulses (Laursen and Salter, 2006). Both breadth and depth depict a firm's openness for external innovation impulses (Chesbrough, 2003). Studying the UK manufacturing sector, Laursen and Salter (2006) find that the relationship between search breadth and depth and innovation performance has an inverted U-shape. This means that while search efforts initially increase a firm's performance, there is a trade-off from "over-searching" the environment. At a certain threshold it requires too much management attention (Ocasio, 1997) and has a negative effect on innovation performance.

In a similar vein, Katila and Ahuja (2002) focus on search depth and search scope in the search and problem-solving activities of firms from the robotics industry. Contrary to Laursen and Salter (2006), they define search depth as the extent to which a firm reuses existing knowledge, while search scope indicates how widely a firm explores externally available knowledge. The latter largely corresponds with search breadth as defined by Laursen and Salter (2006). However, Katila's and Ahuja's (2002) definition of search depth puts a stronger emphasis on exploiting the established knowledge base within the firm. Consistent with the results of Laursen and Salter (2006), Katila and Ahuja (2002) observe an inverted U-shaped relationship between the search effort and innovation performance which again points to the negative consequences of too extensive search activities. They also present evidence that the interaction of search breadth and depth is positively related with innovation performance because it increases the uniqueness of recombinations: A deep understanding of firm-specific knowledge assets that is extended towards a new application (scope) creates a unique and more valuable combination of resources.

3 Hypotheses development

The conceptualization of a firm's search strategy along the dimensions of its breadth and depth implies that the targeted knowledge is largely homogeneous with regards to its source. Following Laursen and Salter (2006), a firm focusing, for example, solely on lead customer knowledge can be considered to have an equally broad and deep search strategy as a firm concentrating its search for knowledge completely on universities. This assumption may be correct once the external knowledge has entered the firm and is already assimilated with existing knowledge stocks. However, we expect the homogeneity assumption on the knowledge of a search strategy to fail as long as the knowledge remains outside of the firm boundaries and has yet to be identified. This "scanning" stage is crucial for the successful implementation of external knowledge sourcing (Doz *et al.*, 2001). Todorova and Durisin (2007) point out that the transformation of external knowledge is one of the most important steps for absorbing it. This reflects the fact that external knowledge can be assumed to be highly heterogeneous in nature. Literature has characterized the types of knowledge along several dimensions, ranging from tacit to formal (e.g., Cowan *et al.*, 2000; Dyer and Hatch, 2004; Polanyi, 1967), specific to generic (see e.g., Breschi *et al.*, 2000), embodied to disembodied (Romer, 1990) to consisting of information or know-how (Kogut and Zander, 1992).

We argue that management will define the firm's search strategy for external knowledge based on its source. Put simply, we propose that management choice is not between breadth and depth but that it provides certain directions. These directions should reflect the potential value of a knowledge source and how easily it can be accessed and transferred. This shifts the focus from the recipient firm's absorptive capacity to the source. Several authors question the existence of a generally available pool of external knowledge and favor instead a "relational" perspective of knowledge flows (Dyer and Hatch, 2006; Dyer and Singh, 1998; Lane and Lubatkin, 1998). Knowledge flows should therefore not be described as broad diffusion processes but as targeted dyadic exchanges. Hence, the absorptive capacities of the knowledge recipient are not sufficient to explain it. Successful knowledge flows depend on the context as well as the motivation and capability of the source to share (Dyer *et al.*, 2001; Szulanski, 1996, 2000). A firm's search strategy can therefore be expected to be partner- or even relationship-specific (Dyer and Hatch, 2006). We focus our discussion on three primary directions for a firm's search strategy: market, science and supply.

The market-side has received much attention in recent academic discussion as part of the "market-orientation" of firms originating from marketing literature (for a review see Kohli and Jaworski, 1990). This broader conceptualization emphasizes a shift in corporate culture towards a central focus on creating superior value for customers (e.g. Slater and Narver, 2000). Customers and competitors can be considered the primary elements of a market-driven search strategy. Both groups are necessarily too important to neglect as their actions have an immediate impact on a firm's sales. Impulses from both groups have been found to propel innovation success, in the case of customers even with a high degree of novelty (Lukas and Ferrell, 2000). Particular customers are especially valuable as knowledge sources when their specific demands are anticipatory for larger market shares in the future (von Hippel, 1988). However, identifying these leading customers has been found to be challenging. Customer knowledge is oftentimes tacit, unarticulated and focused on the customer's own myopic needs (Frosch, 1996; Von Zedtwitz and Gassmann, 2002). Literature has therefore cautioned managers not to focus reactively on customers' immediate needs. It is necessary to balance this narrow "consumer-led" approach with proactive measures for identifying long term, latent customer needs (Ketchen *et al.*, 2007; Slater and Narver, 1998, 1999). Competitor knowledge is different with regard to its accessibility. Competitors operate typically in a similar market and technology context (Dussauge *et al.*, 2000). Their knowledge is oftentimes embodied in the products or services available on the market. That makes it easier to identify relevant aspects and absorb them. However, it limits the opportunities for generating economic returns because of the reduced degree of novelty. Competitor centric search strategies have been found to be more likely imitations or "me-too" products (Lukas and Ferrell, 2000). Hence, designing and executing successful market-driven search strategies requires specialized competencies. These are most likely to be found in the firms sales and marketing units because they interact continuously with demanding customers as well as challenging competitors (Asmussen *et al.*, 2009). Experts in the marketing and sales units can be expected to have a developed stock of knowledge which enables them judge the potential value of a market impulse and the channels to access it.

Science driven search strategies require a different set of specialized competencies. Universities are the primary producer of new knowledge and technologies. The knowledge produced has oftentimes a high degree of novelty which provides important business opportunities (e.g. Cohen *et al.*, 2002). What is more, academic incentive systems for knowledge publication and sharing make university knowledge at least in principle a public good (Perkmann and Walsh, 2007). However, university knowledge is frequently further away from commercial application and requires substantial investments in development (Link *et al.*, 2006; Siegel *et al.*, 2004). Moreover, firms require specialized absorptive capacities to assess and transfer it. Assessing the full value of the often tacit and causally ambiguous knowledge may only be possible through joint research activities in which university and firm scientists develop a mutual understanding and language in practice over time (Laursen and Salter, 2006). A science-driven search strategy should therefore be shaped by the competencies in the firm's own R&D department (Asmussen *et al.*, 2009). The skills as well as the personal networks of firm scientists and engineers developed through education and training (Adler and Kwon, 2002) are a necessary prerequisite. Supply-driven search strategies, though, require specialized competencies in the firm's procurement unit (Asmussen *et al.*, 2009). Suppliers can be important drivers of innovation success (e.g. Pavitt, 1984). They provide new materials, equipment and machinery which enable the generation of novel products, services or processes. Crucial parts of supplier knowledge are embodied in the products they supply and therefore they are easier to transfer. Then again, these supplies may also be available to competitors limiting the degree of uniqueness that can be derived. Extracting the full potential of these supply-driven search strategies oftentimes requires dedicated investments in developing, integrating and refining interactions with leading suppliers. These may include early integration in new product development processes, sharing of information or joint research activities. It enables firms to establish relation-specific advantages when dealing with suppliers which are hard to replicate by competitors (Dyer and Hatch, 2006). On the one hand, firms may benefit from accelerated, co-evolutionary knowledge production with suppliers (van Echtelt *et al.*, 2008). On the other hand, Kotabe (1990; van Echtelt *et al.*, 2008) shows that an over-reliance on supplier inputs can limit firm's own capabilities of adjusting technologies in dynamic environments.

As a consequence, we expect that the effects of these search strategies differ with regard to the type of a firm's innovation capability as well as with regard to the firm's environment.

Radical versus incremental innovation

Innovation capabilities can be characterized as being radical or incremental (e.g., Dewar and Dutton, 1986; Subramaniam and Youndt, 2005). In this respect, radical innovations are breakthrough or major changes of a firm's products, services or processes that may lead to obsolescence of existing designs and technologies (Chandy and Tellis, 2000). They disrupt technological trajectories (Gatignon *et al.*, 2004). Contrary to radical innovations, incremental ones focus on existing products, services or processes with the objective to refine and reinforce their ability to create value for the firm (Ettlie, 1983) or to improve and exploit an existing technological trajectory (Gatignon *et al.*, 2004). Consequently, radical (incremental) innovation capability can be defined as a firm's capability to generate innovations that significantly change (refine) existing products, services and processes.

The differences between radical and incremental innovation capabilities receive further substantiation when they are linked to the way firms draw on their organizational knowledge base. Abernathy and Clark (1985) note that radical innovations destroy or significantly diminish the value of a firm's knowledge base while incremental innovations augment the applicability of existing knowledge. Therefore, radical innovation capabilities are based on new knowledge while incremental innovation capabilities draw upon refined or reinforced existing knowledge (Subramaniam and Youndt, 2005). Consequently, a lower degree of novelty of external knowledge is presumably associated with the generation of incremental innovation capabilities while a high degree of novelty should increase the opportunities to create radical innovation capabilities.

In this respect, a market-oriented search strategy has been found to be more likely associated with imitations or "me-too" products (Lukas and Ferrell, 2000). Several authors have also warned of "consumer-led" strategies focusing too narrowly on short-term customer needs instead of anticipating demand shifts proactively (Ketchen *et al.*, 2007; Slater and Narver, 1998, 1999). Knowledge that may be accessed through such a search strategy could be rather familiar and thus not very novel. As a result, we would expect the organizational knowledge base to be refined rather than transformed (Subramaniam and Youndt, 2005), leading to the creation of incremental innovation capabilities.

> Hypothesis 1: Market-driven search strategies propel innovation success with incremental innovations.

In contrast to this, a search strategy based on knowledge from universities or public research institutes can be assumed to provide highly novel knowledge and corresponding opportunities for commercialization (e.g. Cohen *et al.*, 2002). Although university knowledge tends to be publicly available by the journal publication process resulting in difficulties for firms to appropriate the returns from collaborative activities, we believe that firms can differentiate themselves in competition by means of their absorptive capacities resulting in science-driven search strategies. Hence, university knowledge has the potential to transform the organizational knowledge base, leading to the generation of radical innovation capabilities.

> Hypothesis 2: Science-driven search strategies propel innovation success with radical innovations.

Finally, a supplier-driven search strategy may be an important driver for innovation capabilities (e.g. Pavitt, 1984). On the one hand, firms may use suppliers to learn faster, accelerate the product development process and rely on resources created in a co-evolutionary relationship between the focal firm and its network of suppliers (Dyer and Hatch, 2004; van Echtelt *et al.*, 2008). On the other hand, knowledge produced by supplier organizations might not be unique since potential competitors may equally benefit from the organization's expertise. Moreover, Kotabe (1990) finds that firms relying heavily on supplier knowledge may lose relevant manufacturing process knowledge which may cost the firm the opportunity to improve their manufacturing technology in a rapidly changing technological environment.

As a result, the effects of a supplier-driven search strategy are ambiguous and we revert to two competing hypotheses.

> Hypothesis 3a: Supplier-driven search strategies propel innovation success with incremental innovations.

> Hypothesis 3b: Supplier-driven search strategies propel innovation success with radical innovations.

Service versus manufacturing sectors

Interestingly, most studies investigating search strategies draw no distinction between manufacturing and service sectors. The empirical tests in major research are either explicitly limited to firms in manufacturing (e.g. Laursen and Salter, 2006) or rely on patent statistics to trace knowledge flows (e.g. Katila and Ahuja, 2002). The latter approach is implicitly focused on manufacturing firms as several studies show that firms in manufacturing sectors are significantly more likely to patent (e.g. Arundel and Kabla, 1998; Harabi, 1995). We argue that innovation processes in service sectors show important differences compared to those in manufacturing firms. These differences should be reflected in the search strategies of service firms.

Large parts of the differences between innovation in service and manufacturing sectors can be explained by the very nature of the service business. Services have a high degree of intangibility, i.e. often no physical object is traded (e. g. Dolfsma, 2004; Gallouj, 2002; Maleri, 1997; Sirilli and Evangelista, 1998). Instead, services are more closely related to a process or a sequence of operations. Innovative services can be designed, tested and introduced quickly and at comparatively low investment levels (Johne and Storey, 1998). Hence, service businesses often generate, convert and introduce product innovations in an incremental and ad-hoc manner (Dolfsma, 2004; Johne and Storey, 1998; Scholich *et al.*, 2006). The high degree of intangibility makes it more difficult to obtain patent protection for newly developed services since the majority of services is not eligible for patent protection (European Patent Convention, Article 52; Dolfsma, 2004). What is more, production and consumption of these services frequently coincide. Literature refers to this feature as “co-terminality” (Sirilli and Evangelista, 1998). The market-side is therefore closely interlinked with the production of services and knowledge exchange should be more frequent and immediate.

Based on these distinguishing features of innovation activities in services we conclude that market-driven search strategies should be of dominant importance for firms in these sectors. We derive two primary reasons. First, customers of service firms participate closely in the provision of services (e. g. Dolfsma, 2004; Gallouj, 2002; Johne and Storey, 1998). This direct connection provides innovative firms with direct access to relevant customer impulses. Investment barriers in service sectors are relatively low, e.g. for production facilities or logistics, (Macmillan *et al.*, 1985). Hence, service firms have more opportunities to experiment with new ideas which allow them to integrate and test customer impulses quickly. What is more, the lower investment requirements reduce the risks of potential lock-ins. Even customer impulses which turn out to be myopic and not anticipatory for broader market segments may be served profitably. Secondly, service sectors provide more opportunities to benefit from competitor knowledge. Innovations are less likely to be protected by legal instruments like patents (2007). This results in higher potentials for knowledge spillovers which may lead to challenges but also opportunities for quick imitation of new services by competitors. We propose:

> Hypothesis 4: Market-driven search strategies are the dominant search strategies in service sectors with regard to innovation success.

4 Empirical study

4.1 Data

The empirical part of our study is based on cross-sectional data from the third *Community Innovation Survey* (CIS-3), which was conducted in 2001 under the co-ordination of Eurostat. The survey covers the innovation activities of enterprises in the EU member states (all ascending and some neighboring states) during a three-year period from 1998-2000. What is exceptional about CIS-3 is that it offers representative firm data from all EU-27 member states, which are to a great extend relevant to the questions raised in our study. The micro data of CIS-3 also give information on the NACE 2-sector a firm belongs to. This means that it is possible to distinguish between firms in service and manufacturing sectors. As the data are anonymized, it is impossible to identify single firms or to trace the exact answers back to the respective firms. Eurostat uses an anonymization process that consists of five steps: pre-processing of the data, micro-aggregation, global recoding, evaluation of the disclosure risk, data suppression and release of the micro-data file (Eurostat, 2005). Still, the usefulness of anonymized data can be evaluated by comparing them with non-anonymized data. In the case of German data, such a comparison of anonymized with non-anonymized data showed a satisfactory performance, which indicates that the data can consistently be used to reveal structural relationships among the survey variables (Gottschalk and Peters, 2007).

Even though the CIS-3 survey was conducted in all EU member states, the amount of available data is limited to member states that are willing to participate in generating an anonymized database. Our dataset offers micro-aggregated data for 5 of the EU member states, which makes up a sample of 5,022 observations of enterprises from the following countries: Belgium (640 firms), Germany (1,482 firms), Greece (333 firms), Portugal (500 firms) and Spain (2,067 firms). Industries were identified based on the NACE 2-digit classification and grouped according to the standard industry aggregation by technology level (OECD, 2006). Table 1 provides details on the industries represented in our analysis.

Innovation surveys like CIS are self-reported and largely qualitative surveys. This might raise quality issues regarding administration, non-response and response accuracy (for a recent discussion see Criscuolo *et al.*, 2005). However, there are some features incorporated in the survey that limit possible negative effects. The fact that the survey is conducted via mail prevents certain shortcomings and biases of telephone interviews (for a discussion see Bertrand and Mullainathan, 2001). Moreover, the survey is accompanied by extensive pre-testing and piloting in various countries, industries and firms with regards to interpretability, reliability and validity (Laursen and Salter, 2006). In order to improve response accuracy, the questionnaire offers detailed definitions and examples.

Table 1: Industry breakdown

Industry	NACE Code	Industry Group
Manufacturing		
Food and tobacco	15 – 16	Low-technology
Textiles and leather	17 – 19	Low-technology
Wood / paper / publishing	20 – 22	Low-technology
Chemicals and pharmaceuticals	24	High-/medium-high-technology
Plastics / rubber	25	Medium-low-technology
Glass / ceramics	26	Medium-low-technology
Metals	27 – 28	Medium-low-technology
Machinery and equipment	29	Medium-high-technology
Office and computing machinery	30	High-technology
Electrical machinery and apparatus	31	Medium-high-technology
Radio, TV and communication equipment	32	High-technology
Medical, precision and optical equipment	33	High-technology
Motor vehicles and trailers	34	Medium-high-technology
Transport equipment	35	Medium-high-technology
Manufacturing n.e.c. (e.g. furniture, jewelry, sports equipment and toys)	36 – 37	Low-technology
Services		
Transport and storage (land, water, air)	60 – 63	Low-technology
Post and Telecommunications	64	High-technology
Financial intermediation	65 – 67	High-technology
Real estate, renting and business activities	70 – 74	High-technology

A major benefit of CIS-3 lies in the provision of direct, importance-weighted measures for a comprehensive set of sources (Criscuolo *et al.*, 2005). General managers, heads of R&D departments or innovation management are asked directly if and how they are able to generate innovations. Such immediate information on processes and outputs can be added to traditional measures for innovation such as patents (Kaiser, 2002; Laursen and Salter, 2006). That seems to be especially relevant for our research question as service firms have a lower propensity to patent their innovations.

4.2 Variables and method

Measuring success of radical and incremental innovations

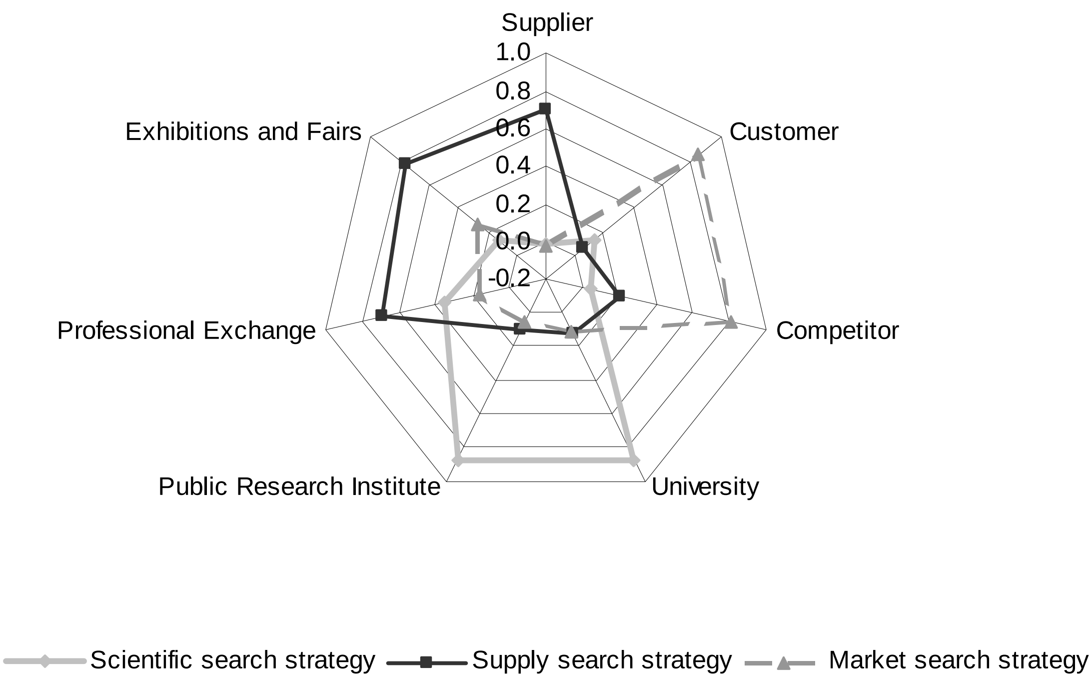
Several authors have introduced different concepts for measuring innovation success (for an overview see Hagedoorn and Cloodt, 2003). One possibility is to use innovation inputs (R&D expenditure) as an indicator for innovation success. Another way is to look at the consequences of innovation, such as patents, new processes, services and products. This is also the perspective we choose for our study. Furthermore, we distinct between radical and incremental innovations by considering a product's or service's degree of novelty. We refer to a product or service to be a radical innovation if it is new to the market whereas we consider a product or service to be an incremental innovation if it is new to the firm. However, the success of an innovation largely depends on market acceptance. For this reason and in order to account for both dimensions of novelty we define innovation success as the share of sales achieved with products new to the firm on one hand and the share of sales achieved with products new to the market on the other and will use it as a dependent variable accordingly.

Capturing search strategies

Measuring knowledge spillovers is a challenging task since they leave no paper trail. Several studies use patent statistics and subsequent citations to capture them (e.g., Galunic and Rodan, 1998; Rosenkopf and Nerkar, 2001a). However, such an approach is not always appropriate, as "not all inventions are patentable, not all inventions are patented" (Griliches, 1990: p.1669). Moreover, the distribution of patenting firms is often heavily skewed. This is for example demonstrated by Bloom and van Reenen (2002), in whose study 72 percent of the sample of almost 60,000 patents by UK firms originate from just twelve companies. Patenting implies the disclosure and codification of knowledge in exchange for protection (Gallini, 2002). The majority of valuable knowledge may therefore never be patented. Moreover, when relying on patent statistics the opportunities to identify distinct search patterns are limited, because they do not offer any information on the relationships between the two firms identified in the patents (e.g. whether they are customers or competitors). Therefore we use survey questions to gain information about external knowledge sources. Importance-weighted answers indicate the value of their contribution. More precisely, respondents are asked to evaluate the importance of the main sources for their innovation activities on a 4-point Likert scale ranging from "not used" to "high". We use information about seven different sources: suppliers, customers, competitors, universities, public research institutes, professional exchanges and exhibition and fairs. In a similar setting Laursen and Salter, 2006 generate indices for the breadth and depth of a firm's search strategy based on these questions. Breadth is measured as the number of different sources used while depth is measured as the number of highly-important sources.

In order to account for the heterogeneity in external knowledge outside of the firm and the corresponding capabilities needed for assessing, transforming and exploiting it successfully, we argue that R&D managers assess the value of search directions, e. g. combinations of knowledge sources, with respect to the idiosyncratic capabilities of the firm. This is in contrast to Laursen and Salter, 2006 who assume that the decision on cooperation is made independently of other knowledge sources' contributions to the innovation process. We therefore apply a principal component factor analysis in order to identify underlying factors. The analysis goes well (Cronbach's alpha scale reliability coefficient: 0.70; Kaiser-Meyer-Olkin measure of sampling adequacy: 0.69) and we identify three factors with an eigenvalue higher than one. We conduct an orthogonal varimax rotation in order to interpret the factors with respect to their informational content. The orthogonality assumption of the factors is tested with a likelihood ratio test which confirms the independence of all factors with an error probability far below 1% (Kaiser and Rice, 1974). Factor loadings identify three individual factors distinctively (above 0.69), as illustrated in Figure 1.

Figure 1: Search directions – factor loadings after varimax rotation



The retained factors reflect our conceptualization of search strategies defined along directions focusing on particular environmental spheres rather than breadth and depth. The first factor is characterized by scientific contribution to innovation processes (public research institutes and universities). Therefore we will refer to this factor as “Scientific search strategy”. Suppliers, professional exchanges and exhibition and fairs load highly positive on the second factor. Hence, we interpret this factor as “Supply search strategy”. In contrast, the third factor reflects a considerable contribution to innovation processes coming from the firms’ market environment (customers and competitors). We interpret this factor accordingly as “Market search strategy”.

With the retained factors we are able to test our hypotheses whether combinations of search strategies reinforce or mitigate innovation success and whether there is an optimum of search intensity. Moreover, these factors allow us to explore the effects of search directions on the degree of radicalism of innovations.[1]

[1] For the ease of data processing we rescale the retained factors to values between 0 and 1.

Control variables

In addition, we include several control variables in our study to account for other factors that may influence the estimation results. Obviously, the radicalism of innovation depends on firms' effort on R&D. Hence, we include the R&D-intensity measured by R&D expenses as share of sales. Furthermore, we control for the effect of continuous R&D activities by adding an additional dummy variable. As firms may be affected by a liability of size or smallness, we add a firm's turnover from the start of the reporting period (1998) in logs. A firm's degree of internationalization is captured by the ratio of exports to total turnover. As our observations stem from various European countries, it is necessary to control for effects of the national regulation environment as well as peculiarities of the domestic innovation system. This is achieved by incorporating country dummies into the regression. If a firm is part of a group, it can spread certain functions among subsidiaries or draw from their resources. We therefore add a dummy variable to control for this fact. Besides, some firms may strictly invest in process innovation which we account for by adding an additional dummy variable.

Estimation strategy

Our dependent variables, the share of sales with new-to-the-firm products and the share of sales with new-to-the-market products, are censored between 0 and 1. We address this issue by estimating Tobit models. Besides, we aim to explore the effects of combining search strategies which we will address by adding interaction terms additionally. Moreover, we account for a possible inverse U-shaped relationship by adding squared factor values additionally. Subsequently we estimate separate models in order to test our hypotheses carefully. Since one of our major goals is the identification of successful search strategies in the service sector we estimate the models again with a subsample of observations from service businesses.

5 Results

Since we are interested in particular characteristics of both the radicalism of innovation and the innovation in the service sector we accordingly analyze our data. Figure 2 shows slight differences in firm characteristics with respect to the innovation's degree of novelty. Firms succeeding with market novelties engage slightly more intensely in the Scientific, the Supply as well as the Market search strategy compared to firms succeeding with firm novelties. Both radical and incremental innovators use Supply and Market search strategy considerably more intensely than the Scientific search strategy. Besides, a significantly higher share of radical innovators conducts research and development activities continuously and is not only successful with product but also with process innovations.

Figure 2: Means of variables according to firms' radicalism of innovation

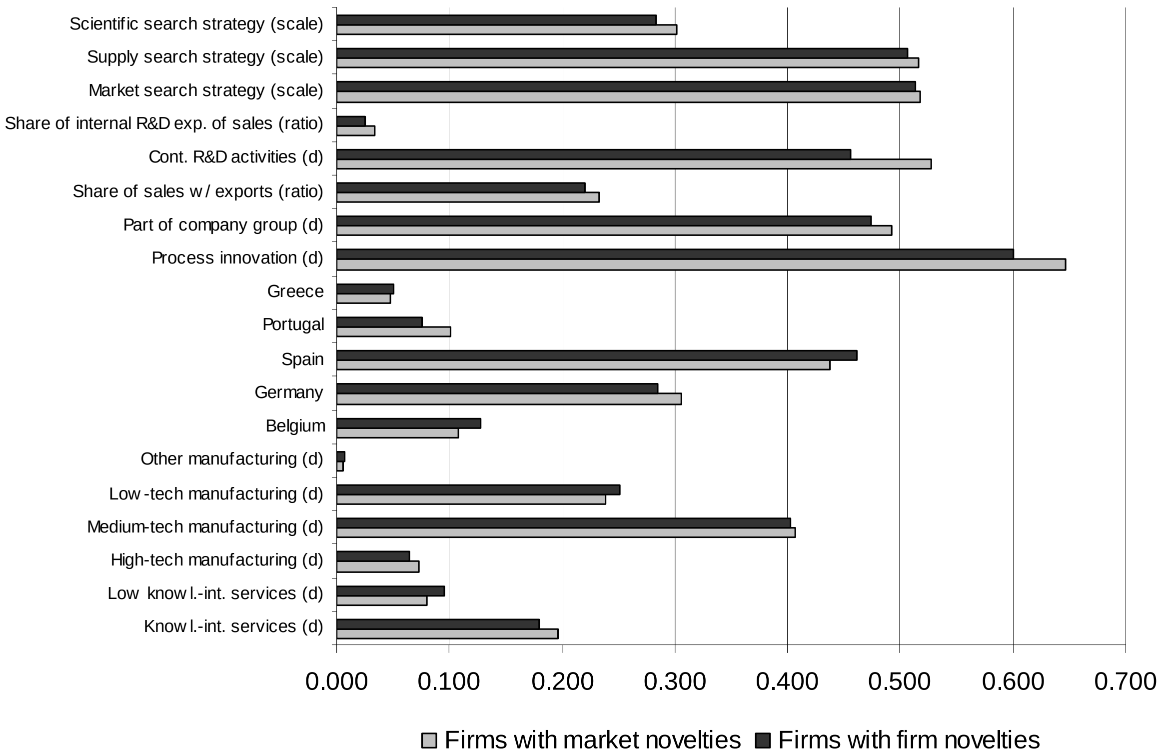
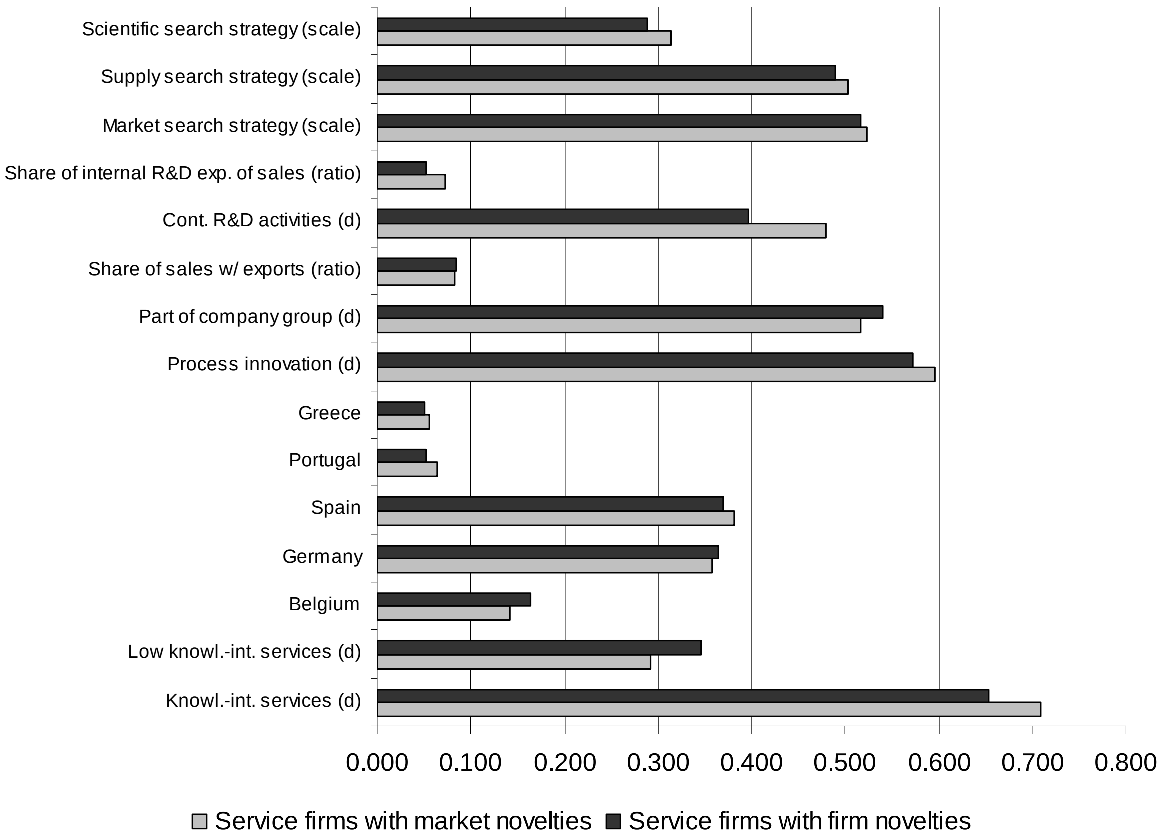


Figure 3 shows the variable means of service firms with respect to the innovations' degree of novelty. Considering general firm characteristics and innovation behavior we observe a similar pattern of differences between radical and incremental innovators as in the overall sample of firms. However, radical innovators in services reveal a less strong focus on drawing on external knowledge from suppliers while Market and Scientific knowledge sources play a comparably important role compared to the overall sample.

In conclusion, the descriptive analysis shows slight differences between search strategies of radical and incremental innovators. Moreover, the results indicate particular differences of search strategies in service firms which may root in characteristic features of service innovation. In the following we will explore these differences with respect to our theory-driven hypotheses more detailed by applying different econometric models to our data.

In order to test our hypotheses regarding the proposed relationship between the innovations' degree of novelty and the contribution of focused search strategies we estimate a Tobit model with the shares of sales generated with radical and incremental innovations as dependent variables. The first two columns of Table 2 show the marginal effects of these estimations for the overall sample. The results presented in column I reveal that we find a positive linear relationship between success with radical innovations, as measured by the share of sales with market novelties and search strategies focusing on either supplier or scientific innovation impulses which is in line with the results of the descriptive analysis. Thus, we find support for our Hypotheses 2 and 3b which state that science-driven as well as supplier-driven search strategies propel success with radical innovations.

Figure 3: Means of variables according to Service firms' radicalism of innovation



The results of column II show that success with incremental innovations, as measured by the share of sales with market novelties is positively affected by a market-driven search strategy. Again, we find a positive effect on innovation success for a search strategy concentrating on supplier impulses. This supports our Hypotheses 1 and 3b which propose a positive relationship between search strategies focusing on external knowledge coming from the market and the suppliers respectively.

A different picture emerges when considering the relationships between search strategies and degrees of novelty in the service sector. Considering the success of radical innovations we find that service firms can find valuable external innovation impulses in all spheres of their environment. The share of sales with products new to the market is positively affected by Scientific, Supply and Market search strategy with Market search strategy showing the highest level of significance. In contrast, the share of sales generated with firm novelties is significantly increased by the Market search strategy and the Scientific search strategy while Supply search strategy loses significance. Therefore, success with incremental innovation is fostered by focusing external knowledge source on scientific and market sources. As we find a robust and strong positive relationship of Market search strategy on innovation success – may it be radical or incremental innovation – the results give support for our Hypothesis 4 proposing that the market-oriented search strategy will be dominant in the service sector.

Table 2: Marginal effects of Tobit estimations[2]

	Share of sales with products new to the market (all)	Share of sales with products new to the firm (all)	Share of sales with products new to the market (services)	Share of sales with products new to the firm (services)
	I	II	III	IV
Scientific search strategy (scale)	0.062*	0.015	0.032*	0.055**
	(0.033)	(0.013)	(0.017)	(0.026)
Supply search strategy (scale)	0.077**	0.023*	0.040**	0.024
	(0.032)	(0.013)	(0.016)	(0.025)
Market search strategy (scale)	0.046	0.056***	0.049***	0.082***
	(0.028)	(0.011)	(0.014)	(0.022)
Share of internal R&D exp. of sales (ratio)	0.345***	0.153***	0.057**	0.099**
	(0.080)	(0.033)	(0.025)	(0.040)
Cont. R&D activities (d)	0.142***	0.040***	0.045***	0.055***
	(0.015)	(0.006)	(0.008)	(0.012)
Share of sales w/ exports (ratio)	0.076***	0.035***	-0.021	-0.046*
	(0.026)	(0.010)	(0.018)	(0.028)
Sales 1998 (log)	-0.018***	-0.011***	-0.005***	-0.012***
	(0.004)	(0.002)	(0.002)	(0.003)
Part of company group (d)	0.010	-0.001	-0.007	0.009
	(0.015)	(0.006)	(0.007)	(0.011)
Process innovation (d)	-0.006	-0.033***	-0.006	-0.032***
	(0.013)	(0.005)	(0.007)	(0.010)
Country dummies included	yes	yes	yes	yes
Industry dummies included	yes	yes	yes	yes
Pseudo R2	0.08	0.14	0.12	0.15
N	5022	5010	1405	1401
LR/Wald chi2	337.16	631.76	172.83	211.81
P-value	0.00	0.00	0.00	0.00
Log likelihood	-2052.87	-1877.15	-621.14	-611.79

(d) for discrete change of dummy variable from 0 to 1
* p<0.10, ** p<0.05, *** p<0.01

Regarding our control variables we find that performing R&D continuously and thus the gradual build-up of absorptive capacity show a positive impact on a firm's innovation success in both samples. This is also true for the R&D-intensity which confirms the importance of both long-term R&D engagements and the height of R&D expenditure for the building of absorptive capacity and innovation success respectively. The remaining control variables in our regression show the expected signs. Firm size measured by the log of sales in 1998 has a negative impact on the innovation success in all model specifications reflecting the fact that the share of new products relative to sales in a small firm is higher than in a large firm. If firms are process innovators they have to allocate limited personal and financial resources to both the development of new processes and new products and services respectively. Therefore, the innovation success will decrease which is supported by our findings of negative effects of process innovation. However, this holds only for the models of incremental innovation. Internationalization as measured by the share of exports of sales has a positive effect on innovation success in the overall sample while there is no significant effect for service businesses when considering market novelties. This result may indicate the local boundaries of services since they are often not provided globally. This argument is supported

[2] The marginal effects of both the country and the industry dummies can be found in Table 3 in the Appendix.

by the negative marginal effects of internationalization in the case of firm novelties. No effect among all model specifications could be found for a firm being part of a company group.

Consistency and sensitivity

Different search strategies cannot be expected to be independent from one another. Extending the discussion on search breadth, depth and scope, Grimpe and Sofka (2009) point to potential complementarities between specific external knowledge, e.g. between market-related impulses from customers and competitors or technology-related knowledge from universities and research institutes. Using data on the innovation activities of manufacturing firms from 13 European countries they find characteristic search patterns as a combination of external knowledge sources fitting together. They show that the adoption of search patterns is industry-specific with considerable differences between and performance implications for high-, medium- and low-technology firms.

On the one hand, a too narrowly defined search strategy may limit a firm's potential to identify promising sources. This reasoning follows the basic rationale that firm's search activities are typically too close to their existing field of expertise. It is less costly and risky to evaluate external knowledge when it is technologically close to existing knowledge stocks of the firm (Cohen and Levinthal, 1990, 1994). However, this narrow scope limits a firm's opportunities in external knowledge acquisition as more technologically diverse knowledge may provide more unique opportunities for combinations and hence a higher degree of novelty (Levinthal and March, 1993). In that sense, Rosenkopf and Nerkar (2001b) call for boundary-spanning knowledge acquisition.

On the other hand, both Laursen and Salter (2006) and Katila and Ahuja (2002) identify an inverse U-shaped relationship between the breadth and depth of firm's search strategies and their effect on innovation performance. This is typically explained with constraints on firm resources including management attention (Ocasio, 1997). Laursen and Salter (2006) argue that firm's can "over-search" (Koput, 1997) in the sense that resources that are overstretched by the evaluation of too many ideas lead to a lower average evaluation quality, foregone opportunities or premature actions leading to suboptimal results. We have argued that firm's search strategies have different directions requiring specialized stocks of knowledge. Hence, the potential effects from over-searching may become visible along two dimensions. First, the negative effects from over-searching may occur when search strategies with different directions are combined. For example, search strategies directed at scientific knowledge and market knowledge draw from the same, overall resource pool of a firm. The respective knowledge stock for one search strategy (e.g. skilled lab scientists in joint research projects with universities) should provide hardly any benefit to the other search strategy (e.g. leading customer knowledge). Exploring both search strategies simultaneously should therefore have a mitigating effect on innovation performance. However, the effects from over-searching may also become visible within one direction of a search strategy. A firm may, for example, rely so heavily on a market-driven search strategy that the skilled managers at the sales department find it increasingly difficult to identify promising lead customers and competitors. As a result, one would expect to find an inverse U-shaped relationship within each search strategy closer to the conceptualization of Laursen and Salter (2006) and Katila and Ahuja (2002).

Therefore, we conducted robustness and consistency checks in accordance with existing literature to check the validity of our results. Additionally, we added interaction variables which combine the search strategy variables and control for possible synergies. Beyond that we also allowed for a nonlinear relationship of search strategies by including their squared in the estimation equation. However, while the linear relationship is robust across sectors and degrees of novelty the finding of an inverted U-shape is limited to the scientific search strategy and its relationship to the share of sales generated with firm novelties.[3] Thus our results are only partly confirm with those of Laursen and Salter, 2006 and Katila and Ahuja, 2002. No significance could be found when including the interaction terms.[4]

6 Discussion and conclusions

We conduct this study to extend existing literature on firm's search strategies for external knowledge. We argue conceptually that search strategies are not homogeneous with regard to the sources they encompass. In that sense, conceptualizations describing search strategies along the dimensions of breadth and depth (Katila and Ahuja, 2002; Laursen and Salter, 2006) may underestimate the degree of heterogeneity among different knowledge sources. What is more, we integrate two additional elements into the stream of research on open innovation and search strategies. First, we focus on varying degrees of novelty in firm's open innovation performance. Some knowledge sources can be expected to provide knowledge with a higher degree of novelty providing more opportunities for radical innovation than others. Second, the nature of innovation activities in service sectors differs significantly from manufacturing sectors. Hence, the particularities of services firms can be expected to be reflected in the success of their search strategies. We test our hypotheses empirically for a comprehensive sample of more than 5,000 firms from five different countries in Europe and find support for most of them. Therefore, conclusions can be drawn with implications for both academic and management audiences.

Our findings extend existing research primarily by emphasizing heterogeneities in firm's search strategies. While the research on diversity (breadth) versus focus (depth) in a firm's search strategy have enriched our understanding of the value of both elements or a search strategy, it does not provide much guidance on which knowledge sources to combine in a broad strategy and which ones to emphasize for depth. We find strong support for our theoretical argument that management chooses a certain direction for the firm's search strategy. These scientific-, supply- and market-driven search strategies differ significantly in the kind of knowledge they can provide and the way they can be accessed by the firm. They

[3] Results are shown in Table 4 in the Appendix.

[4] Results are available from the authors upon request.

can therefore not be assumed to be interchangeable. This is reflected in the value which they can provide in different sectors and, with regards to the degree of novelty, which they provide in innovative products or services. Several studies highlight the increasing importance of service sectors for most modern economies (e.g. Sirilli and Evangelista, 1998). However, empirical tests of open innovation search strategies have primarily focused on manufacturing sectors (Katila and Ahuja, 2002; Laursen and Salter, 2006; Rosenkopf and Nerkar, 2001b). We find that market-driven search strategies are even more important for service firms compared to manufacturing firms. This can be traced back to the literature on co-terminality of production and consumption in service firms. Market-driven search strategies can even provide unique knowledge leading to radical innovations in service sectors. This mechanism cannot be supported in manufacturing firms. However, a too narrow focus on literature emphasizing the role of competitors and customers in service sectors may underestimate the equally important role of knowledge from science and suppliers. Science- and supply-driven search strategies as drivers of innovation success with radically new products and services are important drivers for all firms. Market-driven search strategies bear the danger of over-emphasizing short-term customer needs and imitations of already existing products. Hence, our findings extend existing literature (e.g. Slater and Narver, 1998) and provide pathways for expanding it further. A primary strategy for avoiding "customer-led" traps of incremental innovation may rest in extending the firms knowledge pool with search strategies directed at leading universities and specialized suppliers.

Management implications can be directly derived based on these findings. First, a search strategy focusing narrowly on customers and competitors cannot be expected to provide radically new innovations outside of the service sector. Then again, market-driven search strategies provide incremental innovations which may still be profitable without entailing the increased risk of the radical ones. Second, innovation managers of service firms have strong incentives to broaden their portfolio of promising sources of knowledge outside of the firm. These can be found at universities and from suppliers alike. From the management perspective this may require increased resource commitments at procurement and R&D units to generate the necessary channels for assessing and transferring their particular knowledge. Third, we find strong evidence that firms benefit strongly from their own investments in knowledge production with R&D, especially when engaging continuously and benefitting from accumulated knowledge. Hence, open innovation search strategies appear to be complementary with in-house knowledge production instead of substitutive in nature.

7 Concluding remarks and further research

Our research benefits from a comprehensive dataset which allows us to draw conclusions beyond a certain industry or country context. However, we see room for improvement which may provide pathways for future research. The effects of investments in R&D and open innovation networks may reach their full potential over the long run. Hence, longitudinal studies may help to test and substantiate some of our cross section findings. Besides, qualitative studies may provide further in-depth insights into the mechanisms underlying the different search strategies. This may be especially relevant with regard to how legitimacy and trust can be established and how these mechanisms differ across varying knowledge sources. Finally, manufacturing firms increasingly extend their business activities to services. Investigating the changes in their search strategies underlying these shifts in business models may be a fruitful direction for further research.

8 References

Abernathy, W. J. and Clark, K. (1985). Innovation: Mapping the winds of creative destruction. *Resarch Policy*, 14, 3-22.

Adler, Paul S. and Kwon, Seok-Woo (2002). Social capital: Prospects for a new concept. *Academy of Management Review*, 27(1), 17-40.

Arundel, Anthony and Kabla, Isabelle (1998). What percentage of innovations are patented? Empirical estimates for european firms. *Research Policy*, 27, 127-141.

Asmussen, Christian Geisler, Pedersen, Torben and Dhanaraj, Charles (2009). Host-country environment and subsidiary competence: Extending the diamond network model. *Journal of International Business Studies*, 40(1), 42-57.

Bertrand, Marianne and Mullainathan, Sendhil (2001). Do people mean what they say? Implications for subjective survey data. *American Economic Review*, 91(2), 67-72.

Bloom, Nicholas and Van Reenen, John (2002). Patents, real options and firm performance. *Economic Journal*, 112(478), C97-C116.

Breschi, S., Malerba, F. and Orsenigo, L. (2000). Technological regimes and schumpeterian patterns of innovation. *Economic Journal*, 110(463), 388-410.

Calantone, Roger J., Schmidt, Jeffrey B. and Di Benedetto, C. Anthony (1997). New product activities and performance: The moderating role of environmental hostility. *Journal of Product Innovation Management*, 14(3), 179-189.

Cassiman, Bruno and Veugelers, Reinhilde (2006). In search of complementarity in the innovation strategy: Internal r&d and external knowledge acquisition. *Management Science*, 52(1), 68-82.

Chandy, Rajesh K. and Tellis, G. J. (2000). The incumbent’s curse? Incumbency, size and radical product innovation. *Journal of Marketing*, 64(4), 1-17.

Chatterji, Deb (1996). Accessing external sources of technology. *Technology Management*, 39(2), 48-57.

Chesbrough, Henry W. (2003). *Open innovation: The new imperative for creating and profiting from technology*, Harvard Business School Publishing Corporation, Boston.

Cohen, Wesley M. and Levinthal, Daniel A. (1989). Innovation and learning: The two faces of r&d. *The Economic Journal*, 99(397), 569-596.

Cohen, Wesley M. and Levinthal, Daniel A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly*, 35(1), 128-153.

Cohen, Wesley M. and Levinthal, Daniel A. (1994). Fortune favors the prepared firm. *Management Science*, 40(2), 227-251.

Cohen, Wesley M., Nelson, Richard R. and Walsh, John P. (2002). Links and impacts: The influence of public research on industrial r&d. *Management Science*, 48(1), 1-23.

Cowan, R., David, P.A. and Foray, D. (2000). The explicit economics of knowledge codification and tacitness. *Industrial and Corporate Change*, 9(2), 211-254.

Criscuolo, Chiara, Haskel, Jonathan E. and Slaughter, Matthew J. 2005. Global engagement and the innovation activities of firms, *NBER Working Paper*: Cambridge, MA

Dewar, R. D. and Dutton, J. E. (1986). The adoption of radical and incremental innovations: An empirical analysis. *Management Science*, 32, 1422-1433.
Dolfsma, Wilfried (2004). The process of new service development: Issues of formalization and appropriability. *ERIM Report Series: Research In Management*
Doz, Yves L., Santos, Jose and Williamson, Peter (2001). *From global to metanational: How companies win in the knowledge economy*, Harvard Business School Press, Boston.
Dussauge, P., Garrette, B. and Mitchell, W. (2000). Learning from competing partners: Outcomes and duration of scale and link alliances in europe, north america and asia. *Strategic Management Journal*, 21(2), 99-126.
Dyer, Jeffrey H. and Hatch, Nile W. (2004). Using supplier networks to learn faster. *MIT Sloan Management Review*, 45(3), 57-63.
Dyer, Jeffrey H. and Hatch, Nile W. (2006). Relation-specific capabilities and barriers to knowledge transfers: Creating advantage through network relationships. *Strategic Management Journal*, 27(8), 701-719.
Dyer, Jeffrey H., Kale, Prashant and Singh, Harbir (2001). How to make strategic alliances work. *MIT Sloan Management Review*, 42(4), 37-43.
Dyer, Jeffrey H. and Singh, Harbir (1998). The relational view: Cooperative strategy and sources of interorganizational competitive advantage. *Academy of Management Review*, 23(4), 660-679.
Ettlie, J. E. (1983). Organizational policy and innovation among suppliers to the food processing sector. *Academy of Management Journal*, 26, 27-44.
Eurostat. 2005. Community innovation survey light (cis light), *http://europa.eu.int/estatref/info/sdds/de/inn/inn_cisl_sm.htm*: Luxemburg
Frosch, Robert A. (1996). The customer for r&d is always wrong! *Research Technology Management*, 39(6), 22-25.
Gallini, Nancy T. (2002). The economics of patents: Lessons from recent u.S. Patent reform. *Journal of Economic Perspectives*, 16(2), 131-155.
Gallouj, Faiz (2002). *Innovation in the service economy,* Edward Elgar, Chaltenham, UK and Northhampton, MA, USA.
Galunic, Charles D. and Rodan, Simon (1998). Resource recombinations in the firm: Knowledge structures and the potential for schumpeterian. *Strategic Management Journal*, 19(12), 1193-1201.
Gatignon, Hubert, Tushman, Michael L., Smith, W. and Anderson, P. (2004). A structural approach to assessing innovation: Construct development of innovation locus, type and characteristics. *Management Science*, 48, 1103-1123.
Gemünden, H., Heydebreck, M and Wijnberg, R. (1992). Technological interweavement: A means of achieving innovation success. *R&D Management*, 22(4), 359-376.
Gottschalk, Sandra and Peters, Bettina. 2007. Evaluation of the usefulness of anonymised cis iii data, published by eurostat, for econometric analyses, *ZEW Discussion Paper*: Mannheim
Grant, Robert M. (1996). Toward a knowledge-based theory of the firm. *Strategic Management Journal*, 17, 109-122.
Griliches, Z. (1990). Patent statistics as economic indicators: A survey. *Journal of Economic Literature*, 28(4), 1661-1707.
Grimpe, Christoph and Sofka, Wolfgang (2009). Search patterns and absorptive capacity: Low- and high-technology sectors in european countries. *Research Policy*, 38, 495-506.
Hagedoorn, John and Cloodt, Myriam (2003). Measuring innovative performance: Is there an advantage in using multiple indicators? *Research Policy*, 32, 1365-1379.
Harabi, Najib (1995). Appropriability of technological innovations - an empirical analysis. *Research Policy*, 24, 981-992.

Johne, Axel and Storey, Chris (1998). New service development: A review of the literature and annotated bibliography. *European Journal of Marketing*, 32(3/4), 184-251.
Kaiser, Henry F. and Rice, John (1974). Little jiffy, mark iv. *Educational and Psychological Measurement*, 34(1), 111-117.
Kaiser, Ulrich (2002). An empirical test of models explaining research expenditures and research cooperation: Evidence for the german service sector. *International Journal of Industrial Organization*, 20, 747-774.
Katila, Riita and Ahuja, Gautam (2002). Something old, something new: A longitudinal study of search behavior and new product introduction. *Academy of Management Journal*, 45(6), 1183-1194.
Katila, Riitta (2002). New product search over time: Past ideas in their prime? *Academy of Management Journal*, 45(5), 995-1010.
Ketchen, David J., Hult, G. Tomas M. and Slater, Stanley F. (2007). Toward greater understanding of market orientation and the resource-based view. *Strategic Management Journal*, 28(9), 961-964.
Kleinschmidt, Elko J. and Cooper, Robert G. (1988). The performance impact of an international orientation of product innovation. *European Journal of Marketing,* 22(10), 56-72.
Kogut, Robert and Zander, Udo (1992). Knowledge of the firm, combinative capabilities and the replication of technology. *Organization Science,* 33(3), 383-397.
Kohli, Ajay K. and Jaworski, Bernard J. (1990). Market orientation: The construct, research propositions, and managerial implications. *Journal of Marketing*, 54(2), 1-18.
Koput, Kenneth W. (1997). A chaotic model of innovative search: Some answers, many questions. *Organization Science*, 8(5), 528-542.
Kotabe, Masaaki (1990). The relationship between offshore sourcing and innovativeness of u.S. Multinational firms: An empirical investigation. *Journal of International Business Studies*, 21(4), 623-638.
Lane, Peter J. and Lubatkin, M. (1998). Relative absorptive capcity and inter-organizational learning. *Strategic Management Journal*, 19, 461-477.
Laursen, Keld and Salter, Ammon (2006). Open for innovation: The role of openness in explaining innovation performance among u.K. Manufacturing firms. *Strategic Management Journal*, 27(2), 131-150.
Levinthal, Daniel A. and March, James G. (1993). The myopia of learning. *Strategic Management Journal*, 14(8), 95-112.
Liebeskind, Julia Porter (1996). Knowledge, strategy, and the theory of the firm. *Strategic Management Journal*, 17, 93-107.
Link, Albert N. and Scott, John T. (2005). Universities as partners in u.S. Research joint ventures. *Research Policy*, 34, 385-393.
Link, Albert N., Siegel, Donald S. and Bozeman, Barry. 2006. An empirical analysis of the propensity of academics to engage in informal university technology transfer, *Available at SSRN: http://ssrn.com/abstract=902207*:
Love, James H and Roper, Stephen. 2004. Knowledge sourcing, innovation and performance: A preliminary analysis of irish innovation panel data, *Aston Business School Working Paper*: Birmingham
Lukas, Bryan A. and Ferrell, O. C. (2000). The effect of market orientation on product innovation. *Journal of the Academy of Marketing Science*, 28(2), 239-247.
Lyons, Richard K., Chatman, Jennifer A. and Joyce, Caneel K. (2007). Innovation in services: Corporate culture and investment banking. *California Management Review*, 50(1), 174-191.

Macmillan, Ian, Mccaffery, Mary Lynn and Wijk, Gilles van (1985). Competitors' responses to easily imitated new products: Exploring commercial banking product introductions. *Strategic Management Journal*, 6(1), 75-86.

Maleri, Rudolf (1997). *Grundlagen der dienstleistungsproduktion* (4 ed.), Springer, Berlin.

Nelson, Richard R. and Winter, Sindey G. (1982). *An evolutionary theory of economic change*, Belknap Press of Harvard University Press, Cambridge, MA.

Ocasio, William (1997). Towards an attention-based view of the firm. *Strategic Management Journal*, 18, 187-206.

OECD (2006). *Science, technology and industry outlook*, Paris.

Ojah, K. and Monplaisir, L. (2003). Investors' valuation of global product design and development. *Journal of International Business Studies*, 34, 457-472.

Pavitt, Keith (1984). Sectoral patterns of technical change: Towards a taxonomy and a theory. *Research Policy*, 13(6), 343-373.

Perkmann, Markus and Walsh, Kathryn (2007). University-industry relationships and open innovation: Towards a research agenda. *International Journal of Management Reviews*, 9(4), 259-280.

Polanyi, Michael (1967). *The tacit dimension.*, Doubleday & Co., Garden City, NY.

Romer, Paul M. (1990). Endogenous technological change. *Journal of Political Economy*, 98(5), 71-102.

Rosenkopf, L. and Nerkar, A. (2001a). Beyond local research: Boundary-spanning, exploration, and impact in the optical disk industry. *Strategic Management Journal*, 22(4), 287-306.

Rosenkopf, Lori and Nerkar, Atul (2001b). Beyond local search: Boundary-spanning, exploration, and impact in the optical disc industry. *Strategic Management Journal*, 22(4), 287-306.

Scholich, Martin, Gleich, Ronald and Grobusch, Harald (2006). *Innovation performance: Das geheimnis erfolgreicher dienstleister*, Frankfurt.

Siegel, Donald S., Waldman, David A., Atwater, Leanne E. and Link, Albert N. (2004). Toward a model of the effective transfer of scientific knowledge from academicians to practitioners: Qualitative evidence from the commercialization of university technologies. *Journal of Engineering and Technology Management*, 21(1-2), 115-142.

Sirilli, Giorgio and Evangelista, Rinaldo (1998). Technological innovation in services and manufacturing: Results from italian surveys. *Research Policy*, 27, 881-899.

Slater, Stanley F. and Narver, John C. (1998). Customer-led and market-oriented: Let's not confuse the two. *Strategic Management Journal*, 19(10), 1001.

Slater, Stanley F. and Narver, John C. (1999). Market-oriented is more than being customer-led. *Strategic Management Journal*, 20(12), 1165-1168.

Slater, Stanley F. and Narver, John C. (2000). The positive effect of a market orientation on business profitability: A balanced replication. *Journal of Business Research*, 48(1), 69-73.

Subramaniam, Mohan and Venkatraman, N. (2001). Determinants of transnational new product development capability: Testing the influence of transferring and deploying tacit overseas knowledge. *Strategic Management Journal*, 22, 359-378.

Subramaniam, Mohan and Youndt, Mark A. (2005). The influence of intellectual capital on the types of innovative capabilities. *Academy of Management Journal*, 48(3), 450-463.

Szulanski, Gabriel (1996). Exploring internal stickiness: Impediments to the transfer of best practice within the firm. *Strategic Management Journal*, 17(Special issue), 27-43.

Szulanski, Gabriel (2000). The process of knowledge transfer: A diachronic analysis of stickiness. *Organizational Behavior & Human Decision Processes*, 82(1), 9-27.

Teece, David J., Pisano, Gary and Shuen, Amy (1997). Dynamic capabilities and strategic management. *Strategic Management Journal*, 18(7), 509-533.

Todorova, Gergana and Durisin, Boris (2007). Absorptive capacity: Valuing a reconceptualization. *Academy of Management Review*, 32(3), 774-786.
van Echtelt, Ferrie E. A., Wynstra, Finn, van Weele, Arjan J. and Duysters, Geert (2008). Managing supplier involvement in new product development: A multiple-case study. *Journal of Product Innovation Management*, 25, 180-201.
von Hippel, E. (1988). *The sources of innovation*, Oxford University Press, New York.
Von Zedtwitz, Maximilian and Gassmann, Oliver (2002). Managing customer oriented research. *International Journal of Technology Management*, 24(2/3), 165-193.

Appendix

Table 3: Marginal effects of country and industry dummies

	Share of sales with products new to the market (all)	Share of sales with products new to the firm (all)	Share of sales with products new to the market	Share of sales with products new to the firm (services)
	I	II	III	IV
Greece (d)	0.099***	0.034**	0.016	0.02
	(0.033)	(0.014)	(0.018)	(0.026)
Portugal (d)	0.168***	0.02	0.044**	0.00
	(0.026)	(0.011)	(0.018)	(0.023)
Spain (d)	0.142***	0.120***	0.019*	0.074***
	(0.021)	(0.009)	(0.011)	(0.017)
Germany (d)	0.065***	0.046***	-0.01	0.01
	(0.023)	(0.009)	(0.011)	(0.016)
Medium-tech manufacturing (d)	0.02	0.01		
	(0.016)	(0.006)		
High-tech manufacturing (d)	0.067**	0.036***		
	(0.029)	(0.013)		
Low knowl.-int. services (d)	0.00	0.00		
	(0.025)	(0.010)		
Knowl.-int. services (d)	0.080***	0.031***	0.021***	0.025**
	(0.021)	(0.009)	(0.007)	(0.011)

(d) for discrete change of dummy variable from 0 to 1
* p<0.10, ** p<0.05, *** p<0.01

Table 4: Marginal effects of Tobit models including Squared search strategy variables

	Share of sales with products new to the market (all)	Share of sales with products new to the firm (all)	Share of sales with products new to the market	Share of sales with products new to the firm (services)
	I	II	III	IV
Scientific search strategy (scale)	0.040	0.098**	0.082	0.216**
	(0.028)	(0.045)	(0.057)	(0.088)
Supply search strategy (scale)	0.054	0.063	0.007	0.042
	(0.036)	(0.056)	(0.072)	(0.109)
Market search strategy (scale)	0.001	0.001	0.069	0.117
	(0.029)	(0.046)	(0.059)	(0.090)
Squared scientific search strategy (scale)	-0.031	-0.104*	-0.061	-0.200*
	(0.034)	(0.054)	(0.067)	(0.104)
Squared supply search strategy (scale)	-0.034	-0.039	0.035	-0.014
	(0.035)	(0.055)	(0.072)	(0.109)
Squared market search strategy (scale)	0.010	0.055	-0.018	-0.033
	(0.028)	(0.045)	(0.057)	(0.087)
Share of internal R&D exp. of sales (ratio)	0.089***	0.160***	0.061**	0.115***
	(0.020)	(0.034)	(0.025)	(0.041)
Cont. R&D activities (d)	0.036***	0.039***	0.045***	0.054***
	(0.004)	(0.006)	(0.008)	(0.012)
Share of sales w/ exports (ratio)	0.019***	0.034***	-0.021	-0.049*
	(0.007)	(0.010)	(0.018)	(0.028)
Sales 1998 (log)	-0.004***	-0.011***	-0.005***	-0.013***
	(0.001)	(0.002)	(0.002)	(0.003)
Part of company group (d)	0.003	-0.001	-0.007	0.009
	(0.004)	(0.006)	(0.007)	(0.011)
Process innovation (d)	-0.002	-0.033***	-0.005	-0.031***
	(0.003)	(0.005)	(0.007)	(0.010)
Greece (d)	0.027***	0.035**	0.017	0.019
	(0.010)	(0.014)	(0.018)	(0.026)
Portugal (d)	0.048***	0.018	0.044**	0.002
	(0.009)	(0.011)	(0.018)	(0.023)
Spain (d)	0.037***	0.120***	0.019*	0.074***
	(0.006)	(0.009)	(0.011)	(0.017)
Germany (d)	0.017***	0.046***	-0.009	0.005
	(0.006)	(0.009)	(0.011)	(0.016)
Medium-tech manufacturing (d)	0.004	0.007		
	(0.004)	(0.006)		
High-tech manufacturing (d)	0.017**	0.035***		
	(0.008)	(0.013)		
Low knowl.-int. services (d)	-0.001	0.003		
	(0.006)	(0.010)		
Knowl.-int. services (d)	0.021***	0.030***	0.020***	0.023**
	(0.006)	(0.009)	(0.007)	(0.011)
Pseudo R2	0.08	0.15	0.12	0.15
N	5022	5010	1405	1401
LR/Wald chi2	339.00	637.22	174.05	215.78
P-value	0.00	0.00	0.00	0.00
Log likelihood	-2051.95	-1874.41	-620.53	-609.80

(d) for discrete change of dummy variable from 0 to 1
* p<0.10, ** p<0.05, *** p<0.01

Table 5: Correlations matrix and Variance Inflation Factors

	Scientific search strategy (scale)	Supply search strategy (scale)	Market search strategy (scale)	Share of internal R&D exp. of sales	Cont. R&D activities (d)	Share of sales w/ exports (ratio)	Sales 1998 (log)	Part of company group (d)	Process innovation (d)	Greece (d)	Portugal (d)	Spain (d)	Germany (d)	Medium-tech manufacturing (d)	High-tech manufacturing (d)	Low knowl.-int. services (d)	Knowl.-int. services (d)
Scientific search strategy (scale)	1																
Supply search strategy (scale)	0	1															
Market search strategy (scale)	0	0	1														
Share of internal R&D exp. of sales	0.2154	0.0192	0.0412	1													
Cont. R&D activities (d)	0.3265	0.0575	0.1603	0.2628	1												
Share of sales w/ exports (ratio)	0.1403	0.0045	0.1084	0.0125	0.2647	1											
Sales 1998 (log)	0.1948	0.0043	0.1044	-0.1091	0.2831	0.2705	1										
Part of company group (d)	0.1566	-0.0609	0.0588	-0.0084	0.1894	0.1771	0.4754	1									
Process innovation (d)	0.0641	0.118	-0.0189	-0.0298	0.0819	0.0569	0.1479	0.0707	1								
Greece (d)	-0.0803	0.0456	-0.0968	-0.0772	-0.0921	-0.2	-0.1839	-0.1401	0.0224	1							
Portugal (d)	-0.0596	0.0286	-0.0919	-0.0722	-0.1117	0.0456	-0.0822	-0.0348	0.1019	-0.0886	1						
Spain (d)	0.0264	-0.056	-0.0819	0.0626	-0.0063	-0.0545	-0.0437	-0.0286	-0.069	-0.2229	-0.2781	1					
Germany (d)	0.0526	0.0377	0.2192	-0.0082	0.1061	-0.0438	0.1876	0.0333	0.0058	-0.1724	-0.2152	-0.5411	1				
Medium-tech manufacturing (d)	0.0518	-0.0116	0.0619	-0.082	0.1217	0.2602	0.0946	0.0387	0.0241	-0.0333	-0.0017	-0.0624	0.0531	1			
High-tech manufacturing (d)	0.0604	0.0025	0.0974	0.0676	0.1488	0.0892	-0.0163	0.0029	-0.0539	-0.0562	-0.0376	0.0482	0.0135	-0.2013	1		
Low knowl.-int. services (d) (d)	-0.1114	-0.0393	-0.0297	-0.0799	-0.1679	-0.1504	0.0158	0.0391	-0.0121	0.013	0.0118	-0.1218	0.0586	-0.2767	-0.0855	1	
Knowl.-int. services (d)	0.1016	-0.0428	0.0301	0.2775	0.0477	-0.216	-0.0675	0.0699	-0.0295	-0.0235	-0.0759	-0.0245	0.075	-0.3713	-0.1147	-0.1577	1
VIF	1.19	1.04	1.1	1.25	1.4	1.4	1.58	1.37	1.06	1.63	1.7	2.78	2.63	1.63	1.23	1.36	1.63
Mean VIF	1.53																
N	5,022																