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Keywords: open innovation, open innovation search, SMEs, organizational innovation practices, absorptive capacity, innovation performance

Beyond open innovation in large enterprises: How do small and medium-sized enterprises (SMEs) open up to external innovation sources?

Abstract

The existing literature on open innovation mostly concentrates on large firms. Little is known about the role of open innovation in small and medium-sized enterprises (SMEs). In this paper we explore how SMEs engage in open innovation search. We draw upon a new survey of 1,489 SMEs. Results highlight that SMEs purposively open up to external innovation inputs. We identify variations in how SMEs search for external innovation inputs and empirically classify five strategic types of open innovation search. While these five strategies can be found in different industries, size and age classes, results suggest that a SME's open innovation search strategy is conditioned by its organizational context. We also find that these strategies significantly differ in their ability to improve innovation performance as well as their internal organizational requirements for managing innovation. Our study indicates that both a demand-driven and a widely diversified search strategy can improve the success of SMEs in launching innovations. The latter can even enhance their ability to capture financial value from innovation; however, value capture requires a higher proficiency in managing innovation internally.

Keywords: open innovation, open innovation search, SMEs, organizational innovation practices, absorptive capacity, innovation performance

1 INTRODUCTION

The burgeoning literature on open innovation has revitalized the interest of firms to *purposively* open their business models in order to commercialize not only their own ideas but also external ones (Chesbrough, 2003a; Chesbrough et al., 2006; Lee et al., 2010). So far, empirical research on open innovation mostly concentrates on large multinationals (e.g. Chesbrough, 2003b, see also Dahlander and Gann, 2010). Case studies of pioneers of open innovation like P&G, IBM or Xerox depict that large firms have moved away from relying solely on their internal Research & Development (R&D). They describe in a very detailed manner how these multinationals tap into different types of external innovation sources (Chesbrough, 2003b; Dodgson et al., 2006). Furthermore, some recent quantitative empirical studies on selected aspects of open innovation provide evidence that open innovation positively shapes a firm's innovation performance (Laursen and Salter, 2006).

Despite the relevance of existing scientific work on open innovation, there are numerous gaps. First, open innovation has hardly been studied in small and medium-sized enterprises (SMEs) (exceptions are Lee and et.al., 2010; van de Vrande et al., 2009). SMEs have less financial resources for innovation and fewer technological assets, and thus, researchers generally pay less attention to innovation and innovation management in SMEs (Acs and Audretsch, 1987). However, prior research highlights that despite these limitations in resources and assets SMEs are important for different types of innovation – technological or non-technological ones (Acs and Audretsch, 1987; Vossen, 1988). Recent discussions emphasize that SMEs play an increasingly predominant role in the today's innovation landscape (Chesbrough, 2006b). Second, little is known about how SMEs engage in open innovation to identify and source external knowledge. SMEs rely "by nature" more heavily on inter-organizational relationships and external ties to remain competitive (Edwards et al., 2005). However, our understanding of external ties for innovation in SMEs is mostly restricted to collaborative relationships and alliances (e.g. Baum et al., 2000; Lee et al., 2010). We need a better understanding on how SMEs *purposively* search for external ideas and knowledge, and specifically, how they combine different types of external sources. Third, there is no study that draws upon a large database to analyze open innovation in SMEs across different industries and countries. Fourth, we have little

understanding of how "openness" in SMEs is grounded in a firm's internal innovation potential and organizational facilitators for innovation. SMEs rarely engage in "formal" R&D as large firms do (Vossen, 1988). However, internal organizational practices and resources for innovation are important "facilitators" of innovation and may also interrelate with a firm's strategy to open up to external innovation inputs.

This paper investigates open innovation in SMEs. It is the first study that explores the role of purposive search for external ideas (referred to as *open innovation search*) in SMEs. We aim to present an empirical typology of open innovation search that describes different strategic types of how SMEs open up to external innovation sources. We also aim to understand the differences between these strategies of open innovation search in terms of innovation performance and a firm's internal organizational facilitators for innovation.

The paper is organized as following: In section 2, we briefly introduce open innovation and open innovation search and also reflect on internal organizational innovation "facilitators" as antecedents to absorptive capacity. Afterwards, section 3 presents the analytical framework of our exploratory empirical study. In section 4 we provide details on data, measures and statistical methods before we continue with the results of our empirical analyses. This study draws upon 1,489 firm-level datasets of SMEs in Europe. Finally, we conclude and discuss contributions of our research to existing literature, limitations and future research directions.

2 A BRIEF REVIEW OF LITERATURE: OPEN INNOVATION, OPEN SEARCH AND INTERNAL "FACILITATORS" OF OPENNESS

2.1 Open innovation, inbound innovation and open innovation search

Traditionally, large established firms relied on their own R&D departments and favoured a closed innovation model where all innovations are under the firm's control (Chandler, 1962; Chesbrough, 2003a; Teece, 1986). This "closed innovation model" is contrasted with the open innovation paradigm that describes a new cognitive framework for a firm's strategy to profit from innovation (Chesbrough et al., 2006). It supports firms to purposively use inflows and outflows of knowledge to accelerate internal innovation, and to expand markets for external use of innovation, respectively (Chesbrough,

2006a, p.1). Most research on open innovation differentiates between two concepts of open innovation: *inbound* where new ideas flow into an organization and *outbound* where internally developed technologies and ideas can be acquired by external organizations with business models that are better suited to commercialize a given technology or idea (Chesbrough, 2006b). Depending on the financial flows involved, both concepts can be either pecuniary or non-pecuniary in nature (Dahlander and Gann, 2010). A review of existing empirical research on open innovation reveals that a firm's *open innovation search* strategy (Lakhani et al., 2006; Laursen and Salter, 2006) describes an important form of non-pecuniary inbound innovation (Dahlander and Gann, 2010). Open innovation search strategies define how firms organize their search for external knowledge outside their organizational boundaries sources. In their empirical study (one of the rare examples of studies on open innovation that are based on a large scale database of large UK manufacturing firms) Laursen and Salter (2006) concentrate on the *breadth* of a firm's search strategy. Breadth represents the number of different external innovation actors each firm draws upon in its innovation activities to source external knowledge (Laursen and Salter, 2006). They provide empirical evidence that openness, measured as the breadth of search, positively affects a firm's financial innovation performance. However, there are substantial variations in the degree of openness among large firms. Apparently, not all potential sources are of value for the innovating firm (Laursen and Salter, 2004). For example, R&D sources such as universities, research labs or suppliers seem to be highly relevant sources for pioneering firm such as P&G; customers and users may play a less significant role (Huston and Sakkab, 2006). Thus, it is important to concentrate on the particular nature of the external innovation sources in a firm's open innovation search strategy to enrich our understanding of open innovation search in SMEs (Dahlander and Gann, 2010; Gassmann, 2006).

2.2 Absorptive capacity and internal organizational facilitators of innovation

Case studies on open innovation in large firms highlight that corporate R&D laboratories are important vehicles for absorbing external ideas and mechanisms to integrate external knowledge into internal innovation processes (Chesbrough et al., 2006). Most of existing work on open innovation considers internal R&D as a necessary complement to openness (Laursen and Salter, 2006). This highlights that open innovation, and in particular inbound innovation, requires a firm to develop its a*bsorptive*

capacity, which describes a firm's ability to absorb external knowledge (Caloghirou et al., 2004; Cohen and Levinthal, 1990; Lenox and King, 2004; Todorova and Durisin, 2007; Vanhaverbeke et al., 2008; Zahra and George, 2002). Prior research argues that absorptive capacity develops as a by product of investment in R&D or technical training (Zahra and George, 2002). In addition, in their seminal work Cohen & Levinthal (1990) already pointed out that organizational practices within the firm's boundaries are also important antecedents to the successful absorption of external ideas (Cohen and Levinthal, 1990). Research on "internal" capabilities for innovation discusses a range of different practices and routines for managing innovation at an organizational level (Bessant et al., 2009; Pavitt, 2002). They can be classified along a continuum with two contrasting ends: Some are formal and others organizationally embedded and informal (Ernst, 2002; Freeman and Engel, 2007; van de Meer, 2007; Pavitt, 1998; Pavitt, 2002). To understand how open innovation search is grounded inside the firm such internal organizational practices need to be linked to a firm's open innovation search strategy.

3 THE ANALYTICAL FRAMEWORK: OPENNESS OF SMES' INNOVATION MANAGEMENT

Our review of existing literature provides the conceptual foundation to investigate open innovation in SMEs. In this section, we present an analytical framework of open innovation search in SMEs. It builds upon existing open innovation research and considers the particular nature of open innovation in SMEs.

3.1 Open innovation in SMEs

SMEs are a relevant source of innovation. SMEs do have the capacity for radical, new-to-the-world innovation; not just large firms (Acs and Audretsch, 1987; Laursen and Salter, 2004). However, their innovation models and activities differ from those of large firms. While they are usually more flexible, less formalized and fast decision makers, their financial resources for internal R&D are limited (Acs and Audretsch, 1987; Bessant, 1999; Lee et al., 2010; van de Vrande et al., 2009). In addition, they cannot cover all innovation activities required to successfully realize an innovation (Lee et al., 2010); thus, external innovation and operational assets are highly relevant and attractive to SMEs (Baum et

al., 2000). As a natural consequence SMEs may tend to engage more regularly in inbound open innovation. Inbound open innovation search that is non-pecuniary in nature may be highly attractive to SMEs in order to improve their own innovation performance (van de Vrande et al., 2009; Harryson, 2008). Non-pecuniary open innovation search is less resource intensive than acquiring innovation inputs through the market place. External acquisitions require expertise and control over a number of elements in a firm's innovation network which SMEs regularly lack (Dahlander and Gann, 2010). Due to risk involved when opening up to external influences, we assume that *purposive* and *non-pecuniary* open innovation search is an important strategic dimension of innovation in SMEs. We also hypothesize that there are different strategies of open innovation search in SMEs as not all sources are of equal value to innovating firms.

3.1.1 Characteristics of open innovation search in SMEs

Essentially, open innovation search can span a range of different types of organizations. Each potential external innovation partner relates to different knowledge flows and can provide access to very different knowledge domains such as science, technology and product-markets (Li et al., 2008; Sidhu et al., 2004; von Hippel, 1988). We emphasize that open innovation search implies non-pecuniary *direct interactions* with external actors rather than passive search along knowledge trajectories. Across different SMEs a variety of patterns of open innovation search may exist as the value to be expected from each innovation source and the accessibility can significantly alter. Thus, the combination of different innovation sources rather than the total number of innovation sources defines a firm's open innovation search strategy. Key sources and directions of open innovation search are as following:

Interactions along the value chain among customers, indirect customers and suppliers: Sourcing along the traditional value chain might be a valuable approach for SMEs. SMEs might search "downstream" in order to get access to "sticky information" on customer needs, customer context and customer experience. Such information is tacit and difficult to articulate (Reichwald and Piller, 2006; von Hippel and von Krogh, 2006). The involvement of "indirect" customers/users (e.g. the car drivers rather than car manufacturers for automotive suppliers) may provide new insights about new business opportunities beyond existing products and markets (Enkel et al., 2005). SMEs may also aim to search "upstream" to benefit from the specialised (usually technological) expertise of suppliers if they

involve them in new product development. Suppliers can provide ideas for improved technological solutions or process innovations (Tsai, 2009). SMEs may consider suppliers as a relevant source as they concentrate on solutions and commercial value in the short-term (Chesbrough and Prencipe, 2008; Dyer et al., 1998).

Interactions with universities and research organizations: For SMEs, both *universities and research organizations* are a relevant source for inventive and pre-industrial knowledge as science may significantly alter the search for inventions (Tsai, 2009; Fabrizio, 2006; Shinn and Lamy, 2006; Fleming and Sorenson, 2004). University linkages also offer more timely access to inventive trends (Fabrizio, 2009). However, there are a range of barriers to innovation search in university-industry relationships, such as, for example, cultural differences, long-term oriented scientific research versus exploitation oriented research of industrial organizations and incompatible rewards systems with focus on publishing versus "protecting" results (Harryson et al., 2008).

Interaction with experts of intellectual property rights: To access technological knowledge, SMEs may rely on intermediate service providers. Experts on intellectual property rights (IPR) can provide crucial information services that help to bridge the gap between a technological opportunity and its successful commercialization (Bessant and Rush, 1995). They may support search for technological trends and ideas outside the firm's boundary services or ideas on how to appropriate value from a firm's knowledge assets (Bader, 2006; Bennett and Robson, 2005; Bessant and Rush, 1995; Bessant, 1999; Turok and Rako, 2000; Vega-Jurado et al., 2008). However, the involvement of IPR experts is costly and also requires SMEs to deal with complex regulations, and slow processes of patent protection. Thus, it may make it more difficult to quickly move an idea to the commercialization stage (Hurmelinna-Laukkanen et al., 2007).

Interaction with network partners: Relationships with *network partners* are usually long-term oriented and aim for achieving joint value creation rather than efficient transactions. They build upon trust and are characterized by mutual understanding among partners (2005). At the same time, network partners offer SMEs access to complementary innovation assets and also operational complementary assets such as manufacturing, marketing and access channels (Teece, 1986; Christensen et al., 2005); such resources normally require years to be acquired (Baum et al., 2000). Due to the synergistic nature of

interactions, network relationships make it easier to identify, access, and absorb external ideas. For SMEs, network relationships are a highly important source for new ideas (van de Vrande et al., 2009).

3.2 Internal organizational facilitators of open innovation in SMEs

As already pointed out in the seminal work of Cohen and Levinthal (1990), internal organizational practices and resources for innovation are important antecedents of a firm's ability to benefit from external knowledge (Cohen and Levinthal, 1990). As SMEs do hardly engage in "formal" R&D, it is even more important to analyze organizational practices for innovation. These practices link to different components of absorptive capacity. Following the most recent and most in-depth re-conceptualization of Todorova and Durisin (2007), there are five internal organizational facilitators that can be linked to key components of "absorptive capacity" (Todorova and Durisin, 2007; as shown in the figure below): Investment into the innovation potential (1), innovation strategy and planning (2), innovation development processes (3), innovation control (4) and culture for innovation (5).

Figure 1 goes here

Investment into the innovation potential: From a resource based view, financial innovation assets are crucial assets as they provide resource slacks and allow to experiment and engage in more risky innovation projects (Barney, 1991; Teece et al., 1997; Wiklund et al., 2009). A firm's expenditures for innovation also give a rough idea about its internal learning activities and aspiration to explore (Cohen and Levinthal, 1990; Laursen and Salter, 2006). Cohen & Levinthal (1990) argue that without firm's prior knowledge (technological knowledge), organizations are not able to evaluate new information, and thus, fail to absorb it (Cohen and Levinthal, 1990). Thus, we assume that a firm's investment into its innovation potential is an important facilitator of open innovation (Cohen and Levinthal, 1990; Laursen and Salter, 2006; Todorova and Durisin, 2007; Zahra and George, 2002).

Innovation strategy and planning: An innovation strategy supports the identification of future business opportunities and the exploration of new technologies, solution principles or market functions (Adams et al., 2006; March, 1991). Semi-procedural routines for identifying future business opportunities and mapping it with internal competencies and capabilities are essential for innovation strategy making (Mintzberg et al., 1995; Mintzberg, 1991; Goffin and Mitchell, 2005; Adams et al., 2006; Wong et al.,

2007; Pfeiffer, 1971). At the same time, innovation strategy making relates to the first dimension of absorptive capacity and helps to identify the value of new external information and knowledge (Cohen and Levinthal, 1990; Nelson and Winter, 1977; Todorova and Durisin, 2007).

Innovation development processes: Formal systems and procedures for new product development (NPD), such as stage-gate models, have become crucial in innovation management; the benefits of systematic processes have been well documented in NPD research (Brown and Eisenhardt, 1995; Bullinger and Engel, 2006; Cooper and Kleinschmidt, 1987; Cooper, 2008). Such systems support managers to coordinate and integrate the development of innovations in a structure manner (Christiansen and Varnes, 2009). They guide decisions and goal-oriented actions (Benner and Tushman, 2002; Cooper, 2008). Development processes and routines correspond to the second dimension of absorptive capacity. They are organizational antecedents to assimilate or transform new knowledge (Tidd, 2001). Just like absorptive capacity helps to assimilate technological knowledge, support development processes the coordination of external and internal innovation activities.

Innovation control: To turn their innovation potential into value-creating outcomes firms need to measure and manage innovation projects and processes in an *efficient* and goal-oriented manner (Adams et al., 2006; March, 1991). Clearly defined measures and targets for timing, resources and quality of individual innovation projects and innovation processes are essential (Brown and Eisenhardt, 1995; Ernst, 2002; Hauschildt, 2004; Schewe, 1994). Measuring performance is specifically important when launching and commercialising individual innovation activities (Adams et al., 2006). Following the idea of process management, innovation control helps firms to reconfigure activities (Benner, 2007; Goffin and Mitchell, 2005). Thus, it may act as organizational antecedent to the forth dimension of absorptive capacity (to "exploit") (Todorova and Durisin, 2007).

Culture for innovation: Culturally embedded practices direct activities of individuals in an organization and ensure that managerial tasks for innovation are achieved (Nelson et al., 1982; Pavitt, 2002). Culture embraces values, perceptions and assumptions of the member of the organization (Schein, 1985). It influences decisions throughout the innovation process (Ernst and Kohn, 2007; Ernst, 2002; van de Meer, 2007; Wong et al., 2007). A culture for innovation implies and emphasizes space to try out "new things" (Ernst, 2002). At the same time, entrepreneurial spirit and risk taking characterize a culture for innovation. It enables the exploitation of new ideas and directs individuals'

activities in order to turn ideas into commercial value (Schumpeter, 1912). From a temporal perspective, a culture for innovation relates to the early and the latter components of absorptive capacity (Todorova and Durisin, 2007). Thus, we argue that open innovation search is associated with a strong cultural embeddedness of innovation.

4 THE EMPIRICAL STUDY: DATA AND METHODS

4.1 Data and data collection

This research draws upon a coherent set of firm-level data of one benchmarking database on innovation management in SMEs. The benchmarking database was build up in a European initiative aiming for improving innovation management in SMEs[1]. The objective of the data collection was to thoroughly analyze innovation management in SMEs and to compare the capabilities and performance of individual firms at a European level. As there was no measurement instrument available to assess innovation management in SMEs at an organizational level, a new analysis instrument was developed. The benchmarking database provides much richer information than existing databases such as the Community Innovation Survey (CIS) as it covers organizational and firm-level aspects of innovation management in more detail; it also includes measures of open innovation. Various pre-tests and pilots were executed to ensure the interpretability, reliability and validity of the measurement instrument (Engel et al., 2008).

The benchmarking data was collected between April 2007 and August 2009 with the support of trained personnel located in different European countries. Data was collected in an administered manner and based on a structured process. In the preparation phase the objectives of the assessment were introduced and key concepts and terminologies were explained. During the assessment phase the benchmarking instrument was filled in with the assistance of trained coaches. In the final feedback phase each individual firm received an individual analysis report. The results were discussed during an on-site visit. Key informants of SMEs were the main source of information. The owner or CEO of the SME completed the benchmarking questionnaire (Hair, 2010; Sidhu et al., 2004).

[1] The so called IMP³rove initiative was financially supported by the European Commission

More than 30,000 SMEs from 7 industry groups (see below) all across Europe were contacted. Firms that were younger than 2 years were not considered. The sampling was not restricted to innovative firms only. In addition, SMEs could apply directly online to participate in the benchmarking. If they meet the minimum participation criteria (such as the fulfilment of firm size, firm age or industry), they were contacted to start the benchmarking phase. 3,000 SMEs participated in the benchmarking. 2,212 successfully completed the benchmarking questionnaire. 1,680 were visited on site. Further data validation resulted in a benchmarking dataset of 1,489 to be used in statistical analyses. Both R&D intensive and non R&D intensive industries were included in the dataset as recent studies indicate that non R&D industries also move towards a more open approach in innovation activities (Chesbrough, 2006b).

4.2 Sample characteristics: Industry, size and age

The sample consists of rather small and young firms. On average, enterprises employ 23 people (employees as head counts on payroll) and are 14 years in business (mean values for both size and age). Table 1 presents the characteristics of the dataset in terms of industry, size and age class. Knowledge intensive services (KIS), Machinery/Equipment and ICT/Electrical/Optical show the highest representation in the dataset.

Table 1: Sample characteristics in terms of industry class, size and age (SD= standard deviation)

Table 1 goes here

4.3 Measures and variables

4.3.1 Capturing SME's open innovation search

We concentrate on non-pecuniary open innovation search to characterize SME's openness in innovation management. We measure non-pecuniary interactions with each of the following six types of innovation partners individually: Direct customers (1), indirect customers (2), suppliers (3), universities/research organizations (4), IPR experts (5) and network partners (6). The intensity of interaction with the respective source to search for new ideas is measured on a 7-point Likert scale

where 1 denotes “not at all” and 7 denotes “regularly”. If access to a specific source was not available, answers were labelled as “not applicable”.

4.3.2 Measuring innovation performance

To examine the performance difference between the clusters we concentrate on two measures of innovation performance:

Innovation success: The variable innovation success indicates firms’ success in launching their innovations. It measures the percentage of innovation projects where the launch specific targets have been met. By definition it ranges from 0 to 100 percentages. Data of firms that did not specify any targets was excluded from the sample.

Income from innovation: The variable captures a firm’s innovation performance in the last year as a share of income from new products/services that are not older than 3 years. This operationalization is in line with the OSLO manual (OECD/European Communities, 2005).

4.3.3 Measuring internal organizational facilitators for innovation

We also examine how open innovation search is linked to internal organizational innovation potentials. In fact, there is no generally accepted measurement framework for internal organizational innovation practices. Based on the theoretical and conceptual discussions, we develop a new measurement framework to capture internal organizational innovation practices that correspond to different components of absorptive capacity. A set of 13 variables addresses the five components of formal and embedded innovation practices: Investment into the innovation potential, innovation strategy innovation development processes, innovation control, and culture for innovation. A multi-item instrument was used to operationalize the components. Items have interval or metric scales. Principle component analysis (PCA) was applied to compose the different dimensions.

4.4 Statistical methods

This study is exploratory in nature. To explore open innovation search in SMEs we rely on cluster analysis and descriptive methods. In addition, preparatory analysis included the composition of measures for internal organizational innovation practices.

4.4.1 Cluster analysis

The objective of cluster analysis was to sort firms that apply similar approaches of open innovation search strategies into homogenous groups (Hair, 1998). As suggested in methodological discussions on cluster analysis, we applied a combination of hierarchical and non-hierarchical cluster analysis techniques. This helps to obtain a more robust taxonomy. We consider all six variables that measure interactions with different types of external innovation partners as cluster variables to explore how firms search for external innovations. All cluster variables were measured with 7-point Likert scales. Thus, it was not required to standardize the variables (Hair, 2010). First, we applied hierarchical cluster analysis. We chose Ward's method and the squared Euclidian distance measure. The hierarchical cluster analysis allows for an effective identification of a reasonable range of the cluster numbers and potential cluster seeds (Ketchen and Shook, 1996). An inspection of the graph plotting the heterogeneity measure in relation to the number of clusters reveals an "elbow" at the "four-cluster" solution (Backhaus et al., 2008). However, from a conceptual perspective, the "five-cluster" solution seemed to be even more appropriate. Thus, we took the "five-cluster", "four-cluster", and "three-cluster" solution into consideration for the second analysis phase. Here, we applied a K-means cluster analysis to determine the final cluster profiles; we used the results of the hierarchical cluster analysis as cluster seeds. In prior methodological discussions, this approach has generally been considered as superior to using random starting points in terms of clustering recovery (Punj and Stewart, 1983). K-means analysis revealed consistency of all three cluster solutions. Thus, we decided to further examine the conceptually preferred five-cluster solution. As suggested by several authors we chose a random sub-sample, carried out clustering and compared results with those based on the overall sample (Hair, 2010; Punj and Stewart, 1983). Results confirmed that the five cluster solution is highly robust. Thus, we chose the five cluster solution as the final one.

To further validate, profile and examine the specifics of the five-cluster solutions we applied one way variance analysis for each individual cluster variable and contextual variables such as firm age and firm size. A non-parametric Kruskal Wallis test was used to understand the industry context. We also investigated differences between the cluster means for variables measuring firm performance and internal organizational innovation practices (Hair, 2010). This allows for an examination whether there are significant differences between the clusters in terms of firm performance and also internal

organizational practices. To further deepen our understanding of the performance differences, we applied a post-hoc test (Scheffé procedure) to compare individual pairs of cluster means. We used a conservative procedure, the Scheffé one (Hair, 2010, p.473).

4.4.2 Empirical composition of managerial innovation practices

Preparatory analysis included the composition of measures for organizational innovation practices. We applied principle component analysis (PCA) to compose the innovation practices and investigate their convergence.

We apply principal component analysis (PCA) with VARIMAX rotation (Hair, 1998). All 13 variables were standardized to increase content validity. To ensure the appropriateness of the explorative factor analysis, we run pre-analysis checks (Hair, 1998). Measurement Sampling Adequacy (MSA) analysis showed that there are sufficient correlations in the data matrix. For 12 variables the MSA was higher than 0.7. Only one variable was close to 0.5 ($p<0.001$). We applied the Bartlett test of the sphericity and the Kaiser-Meyer-Olkin measure to justify the factor analysis. KMO and Barlett-test results met common standards (KMO=0.779; p(Barlett)=0.000). We applied the *latent root criterion* for the identification and selection of the factors (Hair, 1998)). A first inspection of the "un-rotated" factor matrix suggested that there are five factors. The final number of factors was extracted once the results were rotated. As a result we obtain a 5-dimensional measurement solution explaining 65.52 % of the overall variance. They confirm the content validity of the different types of organizational practices spanning formal and informal practices discussed in our hypotheses. Table 2 presents the rotated factor matrix with the factor loadings for each variable. Results reveal that managerial practices converge into five distinct dimensions which link to different components of absorptive capacity.

Table 2: Rotated factor matrix with factor loadings

Table 2 goes here

5 RESULTS: EMPIRICAL EVIDENCE OF OPEN INNOVATION IN SMES

In the following sections, we present the results of our empirical study on the open innovation search in SMEs. First, we describe the level of openness in SMEs before we discuss different open innovation

search strategies. These strategies highlight different approaches of how SMEs engage in open innovation search. Afterwards, we investigate differences between these strategies in terms of industry, age and size classes to understand whether organizational context conditions a firm's open innovation search. We also examine performance differences. Finally, we pay attention to internal conditions of openness and investigate whether open innovation search strategies differ in terms of internal requirements for managing innovation.

5.1 Level of openness and relevance of different external innovation sources

Table 3, shows the level of openness in SMEs to search for ideas from different innovation sources across the overall sample. It highlights the relevance of individual innovation sources for innovation management in SMEs.

Table 3: Level of external search across the overall sample

Table 3 goes here

As one may have expected, customers are an attractive innovation source for SMEs in order to learn about "sticky" customer needs. A mean value of 4.7 for the intensity of customer involvement (based on a seven-point Likert scale) points out that SMEs, on average, consider customers as highly relevant source of new ideas (Laursen and Salter, 2006; von Hippel, 1988). Network partners are also considered as an important source (Christensen et al., 2005). This indicates that SMEs leverage well established interaction channels with trusted partners to search for new ideas (Mean=3.9). SMEs do also involve universities and research organizations (mean value of 3.06 based on a seven-point likert scale) to search for new technological knowledge. On average, these interactions are apparently of lower relevance.

5.2 Empirical typology: Patterns of open innovation search in SMEs

Table 4 presents five clusters as the results of our statistical cluster analysis and reports the averages scores of each cluster for each cluster variable measuring the interaction with individual innovation sources. These cluster solutions provide an idea about how SMEs engage in open innovation search and how they combine different types of innovation partners to access external ideas. On the basis of

these scores we label the five groups to characterize their open innovation search: Closed innovators (type 1, 22 % of the firms in the sample), supply-chain searchers (type 2, 17 %), technology-oriented searchers (type 3, 19 %), application-oriented searchers (type 4, 22 %), and „full-scope“ searcher (type 5, 21 %).

These different approaches of open innovation search can be described as following:

Closed innovator (Type 1): Type 1 follows a rather closed innovation strategy and emphasizes internal control of innovation activities. SMEs in cluster 1 do not actively interact with external sources to combine internal and external innovation potentials. Neither do they rely on inputs from actors of their value chain (customers or suppliers) nor do they involve trusted network partners to identify new innovation opportunities. In addition, they do not draw upon scientific and pre-commercial knowledge from universities or research organizations. IPR experts are also not an attractive innovation source. They are reluctant to open up their innovation activities to outside influences. For example, during our fieldwork and follow-up workshops we found a “typical” closed innovator in the electronics sector. The management team of this SME offering services to install network infrastructure stated that ideas for innovation should be developed by internal staff only and should not be shared with others. For them, working with outsiders is risky and implies a competitive threat. Results highlight that closed innovation is a common innovation strategy in the SME sector; and not just among large multinationals.

Supply-chain searcher (Type 2): Firms in cluster 2 are characterized by relatively intensive interactions with direct customers and suppliers in comparison to other external sources. Taking a closer look into the relative weight of the respective sources, data reveals that these SMEs heavily rely on “traditional” supply-chain linkages. Their innovation activities do not rely on input from sources generating pre-commercial and future-oriented knowledge such as universities and research organizations. Existing and well established network relationships with network partners aren’t an important innovation source either.

Technology-oriented searcher (Type 3): Firms in cluster 3 are characterized by a relatively high degree of interaction with *universities, research organizations* and *IPR experts.* This indicates that these SMEs are interested in getting access to inventive trends as early as possible and in sourcing external technological and pre-commercial knowledge. These firms tackle the challenges of

university-industry relationships such as cultural differences and incompatible reward systems. They also heavily rely on innovation inputs from innovation network partners with which they have established trustworthy relationships. These relationships offer important complementary resources to further develop a technological idea. However, they do not put a large emphasis on innovation inputs of actors along the traditional supply chain, such as suppliers and customers. Indeed, technology-oriented searchers do hardly interact with downstream partners, namely direct customers and indirect customers. This suggests that they follow a technology-push innovation strategy and do hardly involve actors positioned at the end of the value chain in the early phases of the innovation activities. One of our "technology searchers" that we interviewed was once spun-out of a research institute more than 15 years ago. To be at the cutting edge of new technological trends, today the firm still heavily draws upon ideas and knowledge of research organizations and universities at a national and international level. It even co-develops its innovation strategy with its research partners.

Application-oriented and demand-driven searcher (Type 4): Type 4 represents the largest cluster in terms of number of SMEs. SMEs of type 4 are application-oriented and demand-driven innovation searchers. This type of SMEs regularly interacts with value chain actors such as customers and suppliers to get access to new ideas. Network partners do also play an important role for new ideas. These firms rank highest in the active involvement of indirect customers. They consider indirect customers and users (which are not direct customers) as the most important input source in relation to other sources. Apparently, they perceive consumers as "value generators" rather than "value receivers" and apply open innovation search to get access to sticky information about customer needs. Technological knowledge and inventive trends are of rather little relevance if SMEs engage in application-oriented search strategies. These firms rank very low in terms of interaction with universities, research organizations and IPR experts.

We visited a firm offering specialized engineering services for sustainable and energy efficient buildings which matches the profile of an application-oriented searcher. When searching for ideas and innovative solutions they regularly involve direct customers (such as the construction firm) and also directly interact with indirect customers including private or public building owners and "users" of energy efficient homes. The engineering service firm delivers "specialized" services which require an intensive and continuous dialog with the customers and users, especially in the early phases of the

innovation process. In our interviews, the management team made clear that it regarded this continuous dialogue as a prerequisite to achieve innovation success in services for energy efficient building management.

Full-scope searcher (type 5): Firms in type 5 are heavily involved in open innovation search, show a strong interest in external ideas from various innovation sources and have built an innovation ecosystem for new ideas. They aim for a high diversity when sourcing external ideas and cover different knowledge domains such as market, technology, and scientific knowledge. Indeed, they heavily interact with all six innovation sources to get access to new ideas and new knowledge. Considering the absolute average score of each external source, SMEs of type 5 show a very strong interaction with universities/research organizations. This indicates their strong interest in inventive trends and pre-commercial knowledge. At the same time, they also rely more heavily on IPR experts than other SMEs. The high average score for interactions with IPR experts indicates that these firms are dedicated to identify best means to appropriate value from either internal or external technological knowledge. They interact with IPR experts to protect their knowledge, source external R&D or search for new means to commercialize their technological competencies. Full-scope searchers also rank highest in terms of interaction with network partners. They open up their innovation activities to get access to complementary resources and to exchange ideas via trusted relationships and well established interaction channels. This indicates that they have understood that they require complementary assets to turn ideas into value and to profit from innovations (average score 5.5). They also regularly assess the demand and market potential of new ideas. They rank very high in direct customers involvement. Overall, their open innovation search is characterized by a high diversity in terms of innovation sources and active involvement. In our fieldwork we interviewed a software company offering customer relationship management (CRM) software in the SME market. This firm matches the profile of a “full-scope” searcher and explicitly describes itself as innovating in the “ecosystem”. To identify new technological trends its R&D people regularly interact with universities, research organizations and IPR experts; they closely work with network partners offering market access or complementary products and services in order to strengthen the value of their own software, e.g. via industry-specific applications and interoperability with other software systems used in SMEs. These partners are a valuable idea source for really new innovations such as the recently introduced

"software as a service" (Saas) CRM platform, which relies on a "on-demand" delivery model rather than a traditional software licensing model. In addition, they directly involve customers to collect ideas on how to improve the usability of the firm's software solutions and on new features to be included in software updates of existing offerings. The management team stated that customers are important to carry out incremental innovations.

Table 4: Results of cluster analyses – Types of open innovation search

Table 4 goes here

As suggested in prior literature, we examined whether there are significant differences between the five strategic open innovation search types in the clustering variables (those variables that we used to cluster the SMEs; Anderson and West, 1996). As shown in
Table 4, one way analyses of variance for each individual variable confirms significant differences between the five cluster solutions in all clustering variables (F-test $p<0.01$ for all cluster variables). Thus, our typology meets basic requirements for high quality cluster solutions.

5.3 Industry, age and size composition

To further enrich our understanding on the different open innovation search strategies and to provide additional evidence of the validity of the clustering, we profiled the clusters in terms of industry, size and age classes.

As for industries, the bio-tech/pharmaceuticals/chemical sectors show a high share of full-scope searchers (see Table 5). 30.7 % of the firms follow a very open and diverse innovation search strategy. Technology-oriented searchers make up the second largest group in these sectors which are well known for science-based innovation and long lead and development times. In the food and beverages sector the demand-driven search strategy is highly popular (25 %). As one may have expected, ICT/electronics/opticals are sectors which is characterized by full-scope searchers (24.3 %) and technology-oriented searchers (23.3 %). Knowledge-intensive services firms are characterised by demand-driven strategies (26.7%) and closed innovators (26.2 %). In the Machinery/equipment sector, closed innovators (23 %) and supply-chain searchers (27.3 %) are very common. Results reveal that these sectors are still dominated by a "not-invented here" culture. This suggests that SMEs from these

sectors are very slow in adopting open innovation or are unable to do so because their customers – large multinationals - have not yet moved towards a more open approach towards innovation. Space and automotive is dominated by "specialized suppliers" which tend to follow a demand-driven strategy when they open up to external influences (27 %). In our smallest industry, the textile sector, we found a large share of full-scope searchers (28.2 %) relying on a divers set of external innovation sources and also demand-driven innovators (28.2 %). A non parametric Kruskal Wallis test shows that these differences are significant at $p<0.001$ (Kruskal Wallis $\chi^2 = 17.94$; df=4). Overall, our results indicate that the five patterns of open innovation search can be found in all industry groups, both in manufacturing and services industries. However, the distribution across industries is not uniform and in some industries some strategies are more prevalent than others. This suggests that open innovation search is not merely a "strategic" choice but might be conditioned by industry conditions.

Table 5: Industry composition of clusters

Table 5 goes here

When profiling the clusters in terms of the firm age, we found that the average age ranges from 23.25 years to 25.41 years. At the first glance, the clusters showed only little differences in the age profile. Thus, we also investigated whether some open innovation search strategies are more prevalent in same age classes than others. As shown in Table 6, one way variance analysis for the variable "age" shows that differences are not significant (F-test not significant; df=4). We conclude that all five strategic types of open innovation search are not associated with firm age.

In addition, we also profiled the clusters in terms of size class. We observe that the average size of SMEs following a value-chain search strategy (average size 54.85 employees) and closed innovation strategy (average size of 55.95 employees) is below the average size of the total sample. In contrast, the size of firms following a "full-scope" search strategy (average size of 81.74 employees) or a technology-oriented search strategy (average size of 100.32 employees) is higher. A one way variance analysis indicates that the differences between the clusters in terms of size are significant at $p<0.01$ (F-value: 5,415; df=4). This indicates that open innovation search strategies are associated with the size of the firm. Firms that are very open and interact with a diverse set of external stakeholders seem to be

"larger" than firms that follow a closed innovation strategy. Strategies of medium-sized (and not small) firms are marked by practices which are more demanding and require more substantial investments such as for examples technology and science-oriented search.

Table 6: Age and size distribution

Table 6 goes here

5.4 Strategic types of open innovation search and innovation performance

To better understand the relevance of different open innovation search strategies respectively, we examined the performance differences between these five strategic types presented earlier.

When profiling each of the five cluster solutions and described them in terms of the average innovation success (success rate of innovation launches) results suggest that there are variations in terms of innovation success: Closed innovators rank lowest in terms of innovation success. They achieve an innovation success rate of 35.22 % which is below average of the total sample (45.35 %). Traditional supply-chain searchers also show a low innovation success rate (40.39 %). While technology-oriented searchers also show a relatively low innovation success (42.22 %), demand-driven searchers show an innovation success rate above average (52.43 %). SMEs that are highly open to external innovation sources and follow a diverse "full-scope" search strategy show the highest innovation success rate (55.38 %). This indicates that openness, and especially a wide and diversified open innovation search strategy, may shape a firm's innovation processes in a positive way. Indeed, a one way variance analysis for the performance variable "innovation success" revealed that there is a significant difference between the five clusters at the significance level $p<0.01$ (F-value=16.613, df=4). A post-hoc test (Scheffé's procedure) further sharpens our understanding of the performance impact of each open innovation search strategy respectively. The comparison of individual cluster pairs shows that full-scope searchers and application/demand-driven open innovation searchers achieve a significantly higher success rate than SMEs that follow a technology-driven, a supply-chain oriented, or a closed innovation search strategy. We identified the highest significant difference in the mean of "innovation success" between "full-scope" open innovation searchers and closed innovators (mean difference of 20 %, $p<0.01$). It highlights the relevance of a widely diversified open innovation

search strategy for a higher innovation success. However, we did not find a significant difference between the average innovation success of "full-scope" searchers and application-oriented innovation searchers. Results suggest that diversity of innovation sources or application orientation is more relevant than inventive search if innovation success and successful commercialisation is a key objective of the innovating firm. Both strategies – full-scope search and application-oriented search - seem to be superior in terms of innovation success than other open innovation search strategies. Interestingly, we did not find significant differences between the technology-oriented searcher, the supply-chain searcher and the closed innovator respectively in terms of innovation success.

Second, we took a closer look into differences between the clusters in terms of income from innovation (as share of total income). As shown in Table 7, closed innovators rank lowest in terms of average income from innovation (30.66 %). In addition, demand-driven innovation searchers also show an income from innovation below the total sample mean (31.7 %). The average income from innovation of SMEs that focus on traditional supply-chain partners when searching for external ideas and knowledge – so called supply chain searchers - is only slightly higher (33.85 %). They are closely followed by technology-oriented searchers that depict an average share of income of innovation of 34.68 %. SMEs of cluster "follow-scope" searcher rank highest with an average share of income from innovation of 42.17 %. These results emphasize the potential to be gained from a wide and diverse open innovation search strategy. A one way variance analysis supports this descriptive analysis. We found significant differences in the average income from innovation between the five cluster solutions at the significance level $p<0.01$ (F-value: 4.724, df=4). A post-hoc test highlights that the "full-scope" searcher significantly outperforms application-oriented searcher and closed innovators in terms of income from innovation. Indeed, the highest difference in terms of mean values was identified between the "full-scope" searcher and the closed innovator. Overall, a widely diversified open innovation search strategy, the "full-scope" search strategy, seems to be superior in terms of financial impact of openness. However, our results do not support the assumption that demand-driven strategies are superior to closed innovation strategies in terms of financial impact. Apparently, demand-driven strategies support the adoption of an innovation but make it more difficult to appropriate and capture financial value from investments into innovation.

Table 7: Innovation performance profile of clusters

Table 7 goes here

5.5 Open innovation and internal organizational facilitators of innovation

To cast light on the internal complements of open innovation search, we examined the internal organizational innovation potential of each search type respectively. We profiled each cluster with the average score of each factor of internal organizational innovation facilitators, namely *investment into innovation potential, innovation strategy and planning, innovation development processes, innovation control, and culture for innovation*. We also ran one way variance analyses and post-hoc tests to look into the significance of the differences between the clusters. As shown in Table 8, "full-scope" searchers score highest in all dimensions (as we used the results of the factor analysis to describe the clusters the table contains negative values). This highlights that a wide open innovation search strategy is associated with an emphasis on internal organizational facilitators of innovation. For example, the CRM software company mentioned earlier, which engages in a "full-scope" search strategy, is highly proficient in managing innovation internally at a strategic, operational and cultural level. Over the last years, the firm has significantly invested in setting up and implementing a well functioning innovation processes and systems. The firm has been awarded several times in national innovation management contests as winner in the category "SME" and also ranks very high in national surveys of "top employers".

One way variance analyses reveals that there is a significant difference between the cluster solutions for all five factor of organizational innovation facilitators at the level $p<0.01$ (F-values see Table 8). We applied a post-hoc test to further detail our understanding on the differences between the different strategies with regard to internal organizational facilitators for innovation.

As for *investment into innovation potential*, a comparison of individual cluster pairs highlights that "full-scope" searchers invest significantly more than the closed innovator, the supply chain searcher, and the demand-driven searcher. For example, the CRM software provider invests on average over the last 10 years a significant share of 30 % of its income into innovation. We found the largest difference between "full-scope" searcher and the demand-driven searcher, indicating that a "full-scope" search

strategy requires significantly higher investment into the internal innovation potential than strategies that leverage contributions from market actors. This is probably to do with the lacking technology and science-orientation of application-oriented search strategies. As one might have expected, technology-oriented searchers do also invest more than application-oriented searchers. The provider of software and engineering services for fluid power applications, one of the technology-oriented searchers that we described earlier, also shows a significant investment into R&D. It is worth pointing out that the difference between "full-scope" searchers and closed innovators is rather small.

For *innovation strategy and planning*, "full-scope" searchers achieve a significantly higher score than application-oriented searchers, supply chain searchers and "closed innovators". Technology-oriented searchers are also diligent in innovation planning; the factor mean of this cluster is significantly higher than the factor means of supply-chain searchers and closed innovators respectively. We found the largest difference in the factor means between "full-scope" searchers and closed innovators. This highlights that SMEs that follow a widely diversified open innovation search strategy emphasize practices and routines of innovation planning. During these planning activities they identify future innovation opportunities and clarify how and where they will open up to external influences. For example, the CRM software company's innovation strategy builds upon a systematic process to develop innovation roadmaps for each product group, market segment and technology platform. These roadmaps build upon inputs from trusted partners. At the same time, they detail whether and how the firm plans to involve external innovation partners throughout the innovation process.

With regard to *innovation development processes*, we also found that "full-scope" searchers significantly differ from all other search types. The largest distance exists between the "full-scope" searcher and the closed innovator.

Innovation control implies that firms manage and measure all phases, from the inception of the idea through to the launch of an innovation, in an integrated and systematic manner. Innovation control also relates to high diligence in managing the commercialization phase in order to achieve a higher success rate. In this regard, a comparison of individual cluster pairs reveals that "full-scope" searchers put a significantly stronger emphasis on innovation control than technology-oriented searcher, supply chain searcher and closed innovators. Indeed, close innovators show the largest gap to "full-scope" searchers. However, "full-scope" searchers do not significantly differ from application-oriented

searchers. The latter ones do also score significantly higher in terms of innovation control than the closed innovators. It underscores that demand-driven searchers focus on commercialization and are dedicated in managing the launch of an innovation. For example, the small firm offering engineering service for energy efficient construction and building management mentioned earlier sets clear targets for each innovation project, in terms of time, quality and costs.

Overall, results highlight that both a "full-scope" and an application-oriented search strategy is associated with a higher degree of internal innovation control and a systematic management and measurement of innovation project launch and commercialization.

Finally, we also looked into differences in terms of *culture for innovation*. The post-hoc tests reveal that full-scope searcher score higher in terms of culture for innovation than technology-oriented searchers, supply chain searchers and closed innovators (however, there is no significant difference between full-scope searchers and application-oriented searchers). Application-oriented searchers do also put a significant higher emphasize on cultural aspects of innovation than technology-oriented searchers, supply chain searchers and closed innovators. These results highlights that two open innovation search strategies – namely "full-scope" search and application-oriented search – are both linked to a strong culture for innovation which may serve as an important facilitator of openness.

Table 8: Profiling different open innovation search strategies in terms of internal organizational innovation potential

Table 8 goes here

Overall, our results highlight that those strategies that are associated with a high innovation success, namely "full-scope" search and application-oriented oriented search, are also linked to a higher proficiency in managing innovation internally. However, there are differences in how firms from these two strategic groups implement internal organizational facilitators. "Full-scope" searchers address all five dimensions of internal organizational innovation and manage all phases of the innovation process, from the inception of the idea through to the innovation launch and commercialization, in a systematic manner. They also show a high proficiency in managing innovation at a strategic level and invest significantly in innovation. In contrast, the application-oriented searchers put their efforts in

operational and commercialization practices as well in fostering their innovation culture. They invest only little in innovation.

6 CONCLUSIONS

To deepen our understanding on the role of open innovation in SMEs, this paper investigated how SMEs open to external innovation sources. We present an empirical classification which details five different strategic types of open innovation search in SMEs in Europe, both in manufacturing and service industries. Results enrich existing literature on open innovation search in SMEs and provide insight in the particular nature and value of five different open innovation search strategies. At the same time they also emphasize the internal component of openness and especially the role of internal organizational antecedents of openness.

6.1 Implications for the literature on open innovation search

First, our results strongly support the idea that open innovation matters for small and medium-sized enterprises and not just for large firms. Our results highlight that SMEs do *purposively* engage in open innovation search strategies representing boundary spanning activities that go beyond inter-organizational network relationships. They open up their innovation processes and source ideas from a variety of different external innovation partners.

Second, our cluster analyses reveal that SMEs choose different strategies to open up to external innovation sources. We identified five strategies of open innovation search which can be labelled as following: closed innovators, supply-chain searchers, technology-oriented searchers, application-oriented searchers, and "full-scope" searchers. There are significant differences between these strategic types: They put different emphasis on the following individual innovation partners and combine these partners in a different way when searching for new ideas: Direct customers (1), indirect customers (2), suppliers (3), universities/research organizations (4), IPR experts (5) and network partners (6). Our results highlight that open innovation search should be considered as multidimensional interactions with different types of innovation partners. Not all external sources and related knowledge domains are of equal value for SMEs. Indeed, open innovation search is not a binary concept – open versus closed (Dahlander and Gann, 2007). We show that the combination of

different innovation sources rather than the total number of innovation sources defines a firm's open innovation search strategy as it has been conceived previously in the concept of "breadth" (Laursen and Salter, 2006). Some strategic types represent firms that emphasize a specific knowledge domain and direction of search, such as for example, the technology-oriented searcher. The "full-scope" searcher follows a widely diversified open innovation search strategy. It leverages the overall ecosystem and spreads the search across technology, science, and market domains.

Third, our results indicate that open innovation can improve the innovation performance of SMEs (and not just of large firms). Results suggest that SMEs should engage in a "„full-scope"" search strategy to improve the commercialization and adoption of an innovation *and* to appropriate financial value from new products and services. Firms that follow a "full-scope" open innovation search strategy, leveraging the overall ecosystems for new ideas, significantly outperform firms that follow a closed innovation strategy in both performance dimensions: innovation success (commercialization) and income from innovation. They are also ahead of technology-oriented searchers, which heavily emphasize external technological or scientific sources but do not rely on IPR experts and customers to ensure value creation and appropriation.

We also show that demand-driven and application-oriented search strategies which combine inputs from suppliers, customers, network partners and – most importantly – indirect customers is also a favourable strategy. It can significantly improve the commercialization and adoption of innovation. However, we identified that "full-scope" innovation search is associated with a higher income from innovation than demand-driven innovation search strategies. To generate financial rewards, a demand-driven strategy doesn't seem to be sufficient. It does not support a firm's ability to capture value from innovation.

Fourth, our results indicate that a firm's open innovation search strategy is contingent upon a firm's organisational context.

While the five open innovation search strategies can be found in all industries, both in manufacturing and services industries, some are more prevalent in some industries than in others. For example, sectors such as biotechnology or information and communication technology (ICT) are characterized by "full-scope" searchers. In service sectors one can find a large number of closed innovators and

demand-driven firms which actively involve customers and end users in the innovation process. "Full-scope" searchers are rather rare.

The nature of a firm's open innovation search strategy is apparently not conditioned by a firm's age. Different patterns can occur across different age classes. In contrast, open innovation search seem to be associated with a firm's size. Firms that follow a "full-scope" strategy and interact with a variety of different innovation partners seem to be larger. Results indicate that large firms follow a strategy that is more demanding and complex. Overall, this suggests that a SME's open innovation search strategy is not merely a strategic choice but seems to be conditioned by factors outside the organizational boundaries such as the nature of industry (Christensen et al., 2005).

6.2 Implications for the literature on internal components of open innovation

Our research highlights that openness requires internal organizational complements that facilitate the absorption of external ideas and knowledge (Laursen and Salter, 2006). We empirically composed five dimensions of internal organizational potentials for innovation that are linked to different components of absorptive capacity (Cohen and Levinthal, 1990); namely *investment into innovation potential, innovation strategy and planning, innovation development processes, innovation control, and culture for innovation*. First, our results highlight that those open innovation search strategies that are associated with a higher innovation success also put more emphasis on internal organizational capabilities. For example, "full-scope" searchers which engage in a wide and diversified innovation search seem to be highly proficient in managing innovation internally. Application-oriented searchers do also emphasize internal organizational facilitators of innovation.

Second, we found that not all dimensions are equally important for each open innovation search type. Some practices are more prevalent in some search types than others. There are differences in internal managerial requirements of the most promising strategies – "full-scope" and demand-driven open innovation search. "Full-scope" searchers address all five dimensions, emphasize strategic, operational and cultural facets of internal organizational capabilities for innovation, and also significantly invest in innovation. In contrast, application-oriented searchers put their efforts mostly in innovation control and commercialization and cultural aspects to foster and govern innovation activities. However, they invest rather little in innovation internally. Overall, closed innovators are paying less attention to

routines and practices to manage innovation internally. Surprisingly, they invest only slightly less than full-scope open innovation searchers. However, they are unable to turn this investment into financial rewards. Overall, results highlight the importance of internal organizational facilitators for innovation (and not just financial dedication) to capture value from openness.

6.3 Limitations and Future Research Directions

The current paper offers new insight into the role of open innovation search in SMEs and presents five strategic types of open innovation search. Results highlight that not all open innovation search strategies might improve innovation performance. They also suggest that open innovation search in SMEs is bounded by external factors and grounded in a firm's internal organizational practices for innovation. Despite the significance of the results, there are limitations that pose further questions to be addressed.

First, our study focused on the analysis of patterns of open innovation search and highlights that there are performance differences. However, we did not rigidly investigate the causal effects of individual innovation sources and different types of open innovation search strategies on a firm's innovation performance. Future research should apply multivariate regression analyses to gain more detailed understanding on the performance impact of individual innovation sources and different open innovation search strategies. To do so, one may also investigate in more detail whether there are complementary or contradicting effects when combining two innovation sources. For example, the superior performance of the "full-scope" searcher may result from the dual involvement of universities/research organizations and customers as joint partners in the innovation process (Johnsen et al., 2006).

Second, our results suggest that open innovation search is not just a strategic choice. A firm's search strategy seems to be bounded by external factors, such industry environment or firm size. Thus, future research should consider in more detail how specific external factors and characteristics of the innovation system, in which the firm is embedded, shape a firm's openness to external ideas (Christensen et al., 2005). For example, it is worthwhile to explore how different appropriability regimes bound a firm's open innovation search. Indeed, openness requires SMEs to reveal some knowledge to outsiders. However, this results in a conflict with the SME's interest in protecting its

intellectual property (IP). This "paradox of openness" describes the risk if firms reveal information outsiders steal the idea (Dahlander and Wallin Martin W., 2006; {Hurmelinna-Laukkanen 2007 #1787). To detail our understanding on open innovation search in SMEs, future research should apply rigid empirical analyses, such as for example multinominal regression analyses, to investigate whether the strength of the IP protection influences a firm's open innovation search strategy.

Third, we also found that there are variations among the different strategies in terms of internal organizational requirements. Thus, future research should also investigate in a statistically rigid manner whether and how internal organizational potentials for innovation do condition a firm strategy to open up to external influences.

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8 TABLES AND FIGURES

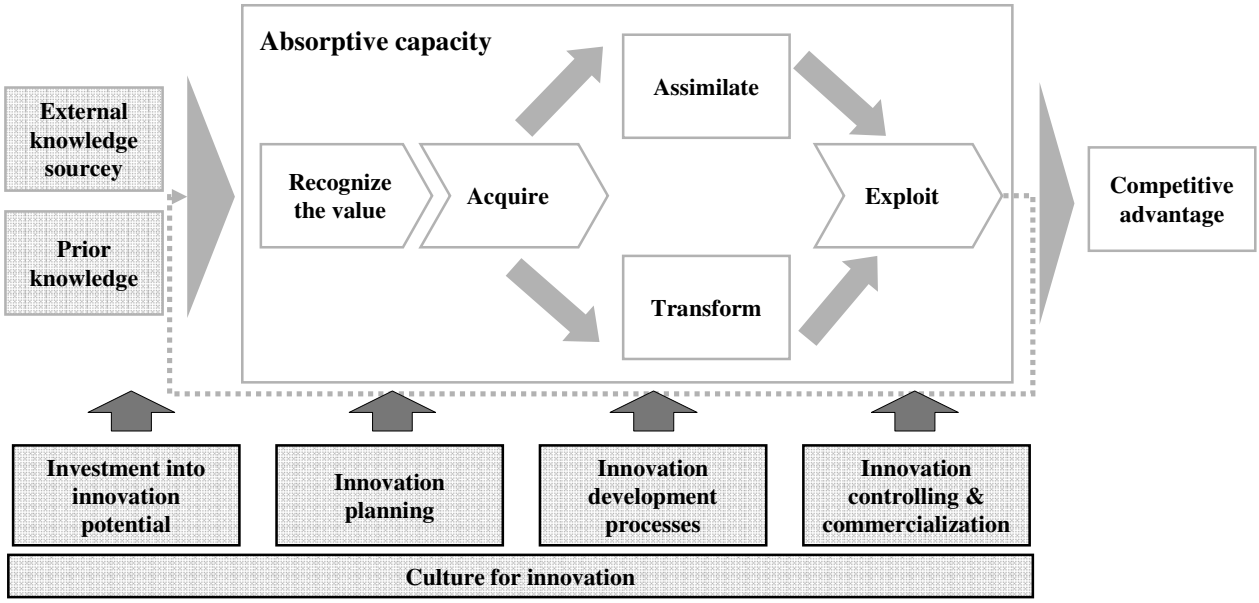

Figure 1: Correspondence of absorptive capacity and internal organizational facilitators

Table 1: Sample characteristics in terms of industry class, size and age (SD= standard deviation)

No	Industry group	No. of firms	Age in years (median)	SD of age	Size in no. of employees (median)	SD of size
1	**Bio Technology**	137	20	31.31	26	128.82
2	**Food / Beverages**	72	17	35.00	50	237.56
3	**ICT / Electrical / Optical**	305	11	22.66	18	133.11
4	**Knowledge intensive services**	412	8	18.39	12	101.37
5	**Machinery / equipment**	357	23	31.15	40	143.11
6	**Space / Aeronautics/ Automotive**	89	18	28.05	55	149.16
7	**Textile**	39	23	45.84	54	74.35
	Total	**1411**	**15**	**28.05**	**23**	**136.23**

Table 2: Empirical composition of internal organizational facilitators of innovation (rotated matrix with factor loadings)

No	Variables	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
1	**Expenditures for innovation over the last 4 years**	0.804				
2	**Budget for long-term oriented project**	0.614		0.343		
3	**Clear vision linked to innovation**		0.817			
4	**Systematic development of an innovation strategy**		0.775			
5	**Systematic process for development of non-product**			0.835		
6	**Systematic process for development of product**			0.821		
7	**Systematic management and controlling of innovation launch**				0.801	
8	**Systematic project controlling and quality management**				0.767	
9	**Systematic process management and controlling of process**				0.700	
10	**Systematic project review**				0.528	0.300
11	**Perceived relevance of improving innovation management**					0.781
12	**Perceived performance in innovation management**					0.701
13	**Cultural readiness**		0.470			0.529
		Investment into the innovation potential	***Innovation Strategy and Planning***	***Innovation Development Processes***	***Innovation Control***	***Culture for Innovation***

Factor loadings > 0.3 reported; Principal component analysis; Varimax Rotation

Table 3: Level of external search across the overall sample

Intensity of external innovation search (individual sources)	Scale	Mean	SD
Direct customer s	1 - 7	4.69	1.94
Indirect customers	1 - 7	3.81	2.09
Suppliers	1 - 7	3.82	2.02
Universities/research organizations	1 - 7	3.06	2.12
IPR experts	1 - 7	2.46	1.93
Network partners	1 - 7	3.87	2.09

N=1411

Table 4: Results of cluster analyses: Types of open innovation search

Cluster variables	Mean values (based on a 7-Likert scale)						
Intensity of external innovation search	**total sample**	**closed innovator**	**supply-chain searcher**	**technology-oriented searcher**	**application-oriented searcher**	**„full-scope“ searcher**	**F test (df=4)**
Direct customers	4.69	2.30	5.48	4.47	5.48	5.87	**313.43****
Indirect customers	3.81	2.47	1.84	3.37	5.61	5.34	**388.78****
Suppliers	3.82	1.94	4.26	2.93	4.58	5.41	**223.98****
IPR experts	2.46	1.37	1.43	2.74	1.53	5.21	**504.06****
Universities/research organizations	3.06	1.52	1.75	5.06	1.76	5.36	**738.19****
Network partners	3.87	2.25	2.92	4.45	4.19	5.50	**157.95****
Number of firms	**1411**	**279**	**286**	**275**	**300**	**271**	

Methods: First Hierarchical Ward; Afterwards K-Means with Ward Results as starting point

Table 5: Industry composition of clusters

	Number of Observations (Percent)					
	Total Sample	**closed innovator**	**supply-chain searcher**	**Technology-oriented searcher**	**application-oriented searcher**	**„full-scope“ searcher**
Bio Technology	137 (100%)	22 (16.1%)	16 (11.7%)	32 (23.4%)	25 (18.2%)	42 (30.7%)
Food / Beverages	72 (100%)	14 (19.4%)	13 (18.1%)	12 (16.7%)	18 (25.0%)	15 (20.8%)
ICT / Electrical / Optical	305 (100%)	60 (19.7%)	46 (15.1%)	71 (23.3%)	54 (17.7%)	74 (24.3%)
Knowledge intensive services	412 (100%)	108 (26.2%)	62 (15.0%)	75 (18.2%)	110 (26.7%)	57 (13.8%)
Machinery / equipment	357 (100%)	82 (23.0%)	81 (22.7%)	46 (12.9%)	69 (19.3%)	79 (22.1%)
Space / Aeronautics/ Automotive	89 (100%)	13 (14.6%)	21 (23.6%)	19 (21.3%)	24 (27.0%)	12 (13.5%)
Textile	39 (100%)	5 (12.8%)	5 (12.8%)	7 (17.9%)	11 (28.2%)	11 (28.2%)
Number of firms	**1411**	**304**	**244**	**262**	**311**	**290**

Cramers V = 0.11**; p<0.01=**, p<0.05 =*

Table 6: Age and size distribution

	Mean values						
Descriptive variables	**total sample**	**closed innovator**	**supply-chain searcher**	**technology-oriented**	**application-oriented**	**„full-scope“ searcher**	**F Test (df=4)**
Age	24.17	24.59	23.51	25.41	24.08	23.26	0.255 (n.s.)
Size	71.62	55.95	54.85	100.32	66.48	81.74	**5.416****

N=1411; p<0.01=**, p<0.05 =*

Table 7: Innovation performance of open innovation search clusters

	Mean values						
Descriptive variables	**total sample**	**closed innovator**	**supply-chain searcher**	**technology-oriented searcher**	**application-oriented searcher**	**„full-scope“ searcher**	**F Test (df=4)**
Innovation Success (in % of projects started)	45.35	35.22	40.39	42.22	52.43	55.38	**16.613****
Income from innovation of last year (in % of total Income)	0.3453	0.3066	0.3385	0.3468	0.317	0.4217	**4.724****

N=1411; p<0.01=**, p<0.05 =*

Table 8: Organizational practices of open innovation search clusters

	Mean values						
	total sample	**closed innovator**	**supply-chain searcher**	**technology-oriented searcher**	**application-oriented searcher**	**„full-scope“ searcher**	**F Test (df=4)**
Factor 1: Investment into the innovation potential	-0.0068	-0.0864	-0.1177	0.1289	-0.2353	0.2977	**12.994****
Factor 2: Innovation Strategy and Planning	0.0127	-0.2558	-0.1564	0.2700	-0.1265	0.3576	**22.417****
Factor 3: Innovation Development Processes	-0.0110	-0.4394	-0.2866	0.1211	0.1006	0.4315	**36.886****
Factor 4: Innovation Control	0.0203	-0.2889	-0.0417	-0.0145	0.1653	0.2721	**13.945****
Factor 5: Culture for Innovation	0.0004	-0.2138	-0.1464	-0.1217	0.1835	0.2611	**13.352****

N=1411; p<0.01=**, p<0.05 =*

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