SMEs’ Radical Product Innovation: the Role of the Internal and External Absorptive Capacity Spheres

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ABSTRACT

This study amplifies the attention for one of the most important (yet often neglected) basic assumptions of the absorptive capacity construct: absorptive capacity does not reside in the firm alone. As such, firms’ capabilities in handling and building on individuals’ absorptive capacity (i.e. absorptive capacity’s internal sphere) are studied: practices increasing knowledge diversity and knowledge sharing among the firm’s employees. We propose a dual role for these mechanisms in the context of radical product innovation: they form a direct wellspring of innovation and they support the externally-oriented absorptive capacity sphere, i.e. the acquisition, assimilation and exploitation of outside knowledge. Small and medium-sized companies in dynamic environments form this study’s setting. The results provide strong support for the hypothesized dual role of the knowledge-related practices that form the firm’s internal absorptive capacity sphere. And the results reveal a different role for knowledge diversity increasing practices vis-à-vis knowledge-sharing stimulating practices.

Key words: absorptive capacity, radical innovation, outside knowledge, knowledge diversity, knowledge sharing
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INTRODUCTION

Many factors are reshaping the world’s competitive landscape, including globalization, trade liberalization, rapid technological developments, and so forth. Even the rules of competition (have) change(d). As those rules increasingly become knowledge-based (Collins & Smith, 2006), firms are challenged to learn and to develop appropriate capabilities faster than their competitors (Lane & Lubatkin, 1998; Van den Bosch et al., 1999). A firm’s set of dynamic capabilities enable it to address rapidly and fundamentally changing environments by supporting the development, integration and reconfiguration of external and internal competencies (Teece et al., 1997). Dependent on this set are the firm’s sustained innovation abilities that constantly fuel its competitive advantage (Branzei & Vertinsky, 2006).

A major dynamic capability directly connected with firms’ innovation activities relates to the set of practices through which firms identify, gain access to, assimilate and utilize various types of knowledge from their environment (Cohen & Levinthal, 1990; Van den Bosch et al., 1999). This dynamic capability is one of a firm’s fundamental learning processes and has been labeled “absorptive capacity”. Well-developed absorptive capacity can refocus, complement and strengthen a firm’s knowledge base, enabling it to adapt to, coevolve with and benefit from environmental changes by renewing itself and/or its products and processes (Liao et al., 2003; Van den Bosch et al., 1999). In their seminal work, Cohen and Levinthal (1990) define absorptive capacity as the firm’s ability to value, assimilate, and commercially utilize new external knowledge. They go on to amplify that developing a firm’s absorptive capacity depends on investments in its members’ individual absorptive capacities and on the firm’s ability to share knowledge internally. This suggests that organizational absorptive
capacity has an external and an internal sphere or side. Externally, absorptive capacity aims at recognizing, assimilating and exploiting information from the environment. Internally, absorptive capacity is concerned with ensuring knowledge diversity across its individual members and knowledge sharing among those individuals. Developing both sides of absorptive capacity enables the firm to tap into diverse external knowledge sources and to be effective in transferring and exploiting this knowledge (Cohen & Levinthal, 1990; Liao et al., 2003; Tsai, 2001).

In spite of the widely recognized pivotal importance of Cohen and Levinthal’s (1990) work and of the surging amount of research on absorptive capacity (Lane et al., 2006), very few empirical contributions have considered both spheres of absorptive capacity. To date, research on absorptive capacity is burdened by two major gaps. First, the bulk of absorptive capacity research has focused on the competitive benefits of absorptive capacity as accessing and exploiting knowledge from outside the firm. Two notable exceptions contrasting this general trend can be found in the contributions of Jansen et al. (2005) and Liao et al. (2003). Second, given the lack of research combining the internal and external spheres of absorptive capacity, it is clear that our knowledge of how both spheres relate to each other is very limited. As a consequence, our view on what constitutes absorptive capacity and how it works in practice remains partially obscured.

The objective of this study is to address both these gaps and to contribute to absorptive capacity research in two ways. First, we advance research by refining the conceptual importance of the neglected internal sphere of absorptive capacity, next to its external side. Second, we add to research linking the external and internal spheres of absorptive capacity. We theoretically and empirically examine how knowledge-related practices affect absorptive capacity, and how both contribute to firms’ innovation performance.
While important for all firms in dynamic environments, in this study we explore the role of absorptive capacity in small and medium-sized companies (SMEs). Several arguments justify this choice. First of all, SMEs may be small in size, but they are large in numbers, making up an impressive share of most economies’ firm populations (Maes et al., 2005). Second, most research and theory building on capabilities in general and absorptive capacity in particular have largely ignored SMEs as a research population (Liao et al., 2003; Zahra et al., 2006). This is somewhat surprising given that SMEs need unique, dynamic capabilities to safeguard their survival and to be able to exploit their innovative position (Sapienza et al., 2006). A well-developed absorptive capacity is such a dynamic capability with a demonstrated, positive effect on SMEs’ external knowledge acquisition, responsiveness and environmental adaptation (Liao et al., 2003). Third, absorptive capacity can steer away SMEs from familiarity, maturity and propinquity competence traps. Given their limited resource base, SMEs are much more likely than large firms to be confined in one or more of these competence traps sooner or later (Liao et al., 2003). Fourth, combining SMEs’ outspoken need for absorptive capacity with their more transparent nature (Katz et al., 2000; Sels et al., 2006) makes them an ideal research population to advance our knowledge of how absorptive capacity can be developed or sustained.

The remainder of this paper is structured as follows. First, we review the literature on absorptive capacity in order to depict its theoretical background and its application in past research. Following, we build our theoretical arguments on the role of both spheres of absorptive capacity for innovation. Third, we clarify our research design. Fourth, we elaborate on the analyses and the results. And finally, we discuss the implications of our study and offer some suggestions for future research.
THEORETICAL BACKGROUND

Our objective in this study is to resuscitate the importance of the multi-level nature of the absorptive capacity construct, all of this in the context of innovation within SMEs. This gives us three main avenues for theoretical clarification: the absorptive capacity construct, its linkage with innovation and its application in the SME context.

The Absorptive Capacity Construct

Cohen and Levinthal (1990) offer the most widely used definition of absorptive capacity. They state that absorptive capacity refers not only to the acquisition and assimilation of information by an organization, but also to its ability to utilize or exploit it. This definition renders absorptive capacity dependent not only on the organization’s interface with the external environment but also on transfers of knowledge across and within organizational subunits (Cohen & Levinthal, 1990: 131). As such, absorptive capacity refers to the whole of the capabilities to recognize the value of new knowledge, to assimilate it, and to apply it to commercial ends (Todorova & Durisin, 2007). The research stream on absorptive capacity is extensive and contains a broad and diverse range of studies. We refer to Lane et al. (2006) for an accurate and profound review of the accomplishments of this impressive research stream.

Within the focus of our study, we point to two important shortcomings of the absorptive capacity literature. First, the research stream has insidiously deviated from (or even neglected) the basic assumptions proposed by Cohen and Levinthal (1990). Lane et al. (2006) demonstrated that nearly 80 percent of the hundreds of studies they reviewed use Cohen and Levinthal (1990) only as a minor citation. These studies make no referral to the construct’s three dimensions (acquisition, assimilation and utilization of new knowledge) and/or cite the construct in a purely ritual way. If researchers want to avoid reifying the absorptive capacity
construct, returning to and building on the original assumptions formulated by Cohen and Levinthal (1990) and others is a must (Lane et al., 2006).

Second and related, research is burdened by a remarkable shortfall of attention to process aspects of absorptive capacity. The origin of this shortcoming lies in the exclusively R&D focus of the earliest absorptive capacity studies. In their review, Lane et al. (2006) found only four studies that have attempted to move absorptive capacity away from R&D to a broader dynamic capability view. However, failing to recognize the importance of processes/capabilities in knowledge acquisition, assimilation and exploitation obscures how absorptive capacity can actually be developed, deployed and maintained. Furthermore, it overlooks the fait accompli that any type of organizational knowledge is created and sustained through the actions and learning of the organization’s individual members (Grant, 1996; Simon, 1991). Neglecting the role of individuals belies a fundamental part of Cohen and Levinthal’s (1990) absorptive capacity logic. It obstructs gaining insight into how competitive advantage is created from individual employees’ knowledge. This type of research fails to recognize absorptive capacity as a multilevel construct, since the individual absorptive capacity of organizations’ members and the organizational structures and processes through which individuals’ learning and knowledge contributions can be integrated to organizational knowledge remain in the dark (Lane et al., 2006). Having an eye for the process side of absorptive capacity in general and gaining insight into firms’ capabilities in handling and building on individuals’ absorptive capacity in particular can advance the research field’s insight on how firms can develop, deploy and maintain their absorptive capacity.

Knowledge, Innovation, and Absorptive Capacity

Organizational knowledge is an attractive resource to build competitive advantage (Grant, 1996; Spender, 1996). In terms of the resource-based view of the firm (Barney, 1991;
Wernerfelt, 1984), organizational knowledge complies with the VRIN conditions (valuable, rare, inimitable and non-substitutable). Further, knowledge is one of the most important inputs for the innovation process. What a firm knows determines what it can do, especially when innovation is concerned (Thornhill, 2006). As absorptive capacity is a knowledge-based construct, it is no surprise that the link between absorptive capacity and innovation has been studied before. Both incremental and radical innovation are interesting to be linked to absorptive capacity since both have (just as absorptive capacity itself) an explorative and an exploitative component, albeit in varying degrees. The bulk of the research, though, has focused on incremental innovation (Lane et al., 2006). In addition to the paucity of research on absorptive capacity and radical innovation, it is our contention that radical (product) innovation is in fact very interesting to be linked to absorptive capacity. Product innovations are much more important than process innovations in many respects (Edquist et al., 2001). And radical innovation is much more explorative than incremental innovation (Ireland, 2003). It calls for changes in many aspects of the firm’s asset and knowledge base (Henderson & Clark, 1990). As such, radical product innovation is much more closely associated with the firm’s learning motive to gain knowledge on and experiment with new ideas and it implies operations beyond the scope of what the firms currently knows (Covin et al., 2003). Distant knowledge elements have to be bridged to come to radical innovative output (Miller et al., 2007).

March and Simon (1958) suggested that most innovations result from borrowing rather than invention. Indeed, it has been recognized that companies cannot rely solely on internal knowledge development for innovation (DeCarolis & Deeds, 1999). Firms also need to absorb relevant knowledge from external sources. Their absorptive capacity becomes critical to their innovation performance. Following this insight, a vast amount of research on the sources of radical innovation has stressed the importance of external knowledge and has provided
empirical evidence for its crucial role for innovation, particularly for firms in dynamic environments (Todorova & Durisin, 2007). However, research on absorptive capacity and innovation has focused almost exclusively on external knowledge access, assimilation and exploitation. Although external knowledge is often higher valued (Menon & Pfeffer, 2003) research has demonstrated that internal knowledge sources can also be of great importance to innovation. For instance, Souitaris (2002) and Thornhill (2006) found employee human capital to be positively associated with innovation. Research on radical innovation combining internal and external sources of knowledge would therefore be very worthwhile. Crucial, though, is that the capacity to create and use new knowledge (based on external and/or internal sources) results from the collective ability of employees to exchange and combine knowledge (Collins & Smith, 2006; Grant, 1996; Nahapiet & Ghoshal, 1998). Thus, even the utilization of mechanisms to acquire and utilize knowledge from external sources depends on the possession of valuable internal knowledge (Almeida et al., 2003) and knowledge combining and exchanging capabilities. In cases of broad exploration (e.g. radical innovation) or distant search activities the need to embrace knowledge creating and sharing capabilities among employees (including lower level) is even more pressing (Siggelkow & Rivkin, 2007).

To summarize, our objective is to amplify the attention for the basic assumptions of the absorptive capacity construct as proposed by Cohen and Levinthal (1990). As they stated, the structure of knowledge exchange (communication) among the subunits of the organization as well as the character and distribution of expertise (knowledge) within the organization are as important as the organization’s interface with the external environment to gain understanding on an organization’s absorptive capacity (Cohen & Levinthal, 1990). This leads us to focus on the process side of firm absorptive capacity and to also consider firms’ capabilities in building on individuals’ absorptive capacity. These mechanisms are investigated in the context of radical product innovation. Radical product innovation usually demands external and internal
sources of knowledge. The ability to create new knowledge from these sources depends on
the firm’s efforts to develop valuable internal knowledge and knowledge integrating and
exchanging capabilities among employees.

**SME Context**

Small and medium-sized companies (SMEs) in dynamic environments form this study’s
empirical setting. Although a substantial amount of research pays no attention to the
justification of the fit between the study’s theoretical objective and its empirical setting, we
consider this issue too important to ignore it. The traditional way for SMEs to build a
knowledge base for innovation or other purposes is to generate knowledge internally (Major
& Cordey-Hayes, 2003). This is favored by SMEs’ flexibility and reduced bureaucracy
(Pelham, 2000). It is, however, questionable for several reasons that these advantages suffice
for SMEs to come to radical product innovation. First, SMEs often possess a narrow
organizational and technological repertoire, resulting in a lopsided stock of knowledge, few
capabilities and a limited capacity to cultivate other capabilities (Zahra & Filatotchev, 2004).
This makes SMEs more prone to the innovation-impeding competence traps (Ahuja &
Lampert, 2001), especially the familiarity (over-emphasis on existing knowledge base) and
propinquity (seeking new knowledge in areas closely related to the current expertise) traps
(Liao et al., 2003). Second and related, the innovative potential of SMEs is hampered by
problems not faced by their larger counterparts, such as SMEs’ lack of resources (financial
resources, manpower, et cetera) (Verhees and Meulenberg, 2004) and the generally excessive
influence of the (founding) management, as posited by upper echelon theory (Hambrick and
Mason, 1984). These problems often prevent SMEs to look for and gain access to the external
knowledge sources they in fact need. As a result, many SMEs unwittingly neglect the role and
importance of external knowledge.
It is our belief that a dual approach could strengthen SMEs’ radical innovation potential. First, the internal knowledge generation, assimilation and utilization should be optimized. Knowledge resources are more amenable to managerial control (Thornhill, 2006), which makes them the ideal target for optimization through SMEs’ flexible structures and routines. SMEs should make better (optimal) use of the knowledge resources and capabilities they actually have. Product innovation in SMEs most often happens through the so-called empowerment system (Vermeulen, 2005). This implies that many organizational members are responsible for innovation. Often these people are not experts with regard to innovation, yet they are highly interdependent on each others’ knowledge to be effective. Smooth knowledge transfer and profound assimilation and correct interpretation of the internal knowledge (in other words: knowledge transferring and creating capabilities) are therefore of crucial importance. Second, it is clear that SMEs should – to the best of their abilities - look for and gain access to external sources of knowledge. External knowledge is even more important for SMEs than for their larger counterparts. In order to be able to innovate firms have to increase their knowledge diversity (Miller et al., 2007). Innovation-focused SMEs must therefore strive to develop absorptive capacity, organizational learning and knowledge-related capabilities, utilizing external knowledge in order to build a broader knowledge stock.

Market knowledge is such an important external knowledge type for SMEs (Major & Cordey-Hayes, 2003). SMEs’ market power is rather limited, increasing their dependence on customers as the main source of market knowledge. Although firms should avoid becoming customer-compelled (Todorova & Durisin, 2007), a deep understanding of customers can help SMEs to find new niche markets and conduct better market segmentation. Making way with a lack of market and customer information destroys a very important impediment for innovation in SMEs (Baldwin & Gellatly, 2003). However, external knowledge (whether customer-related or not) lacks the advantage of close proximity to the firms’ empowered members.
Under conditions of rapid and uncertain change present in dynamic environments the central interface function of the SME’s upper echelon becomes less effective. External knowledge must therefore be brought into the SME’s internal sphere before it can be interpreted and exploited. Stated differently, external information systems in SMEs are highly dependent on the organizational members and on their individual absorptive capacities for the knowledge to be gathered, assimilated and used appropriately. Two conditions that must be fulfilled if taking the external and internal knowledge paths is to pay off for SMEs are developing sufficient individual learning capabilities and ensuring commitment from all organizational members to participate in the knowledge creation process. This need for SMEs to handle and build on individuals’ absorptive capacity if external knowledge is to be exploited forces us as researchers (in line with Cohen and Levinthal’s (1990) original work) to carefully consider the somewhat neglected individual-focused, internal side of firm-level absorptive capacity.

**RESEARCH MODEL AND HYPOTHESES**

In developing our research model we will consecutively focus on the firm’s mechanisms to gain access to, understand and exploit external knowledge as well as on its routines that stimulate knowledge combination and exchange among its employees. Cohen and Levinthal (1990) describe a firm’s absorptive capacity as its ability to identify and recognize the value of new outside knowledge, assimilate it, and apply it to commercial ends. The theoretical work of Lane et al. (2006) firmly builds on Cohen and Levinthal (1990) logic, yet it takes a more profound process-oriented perspective. Lane et al. (2006) distinguish between three sequential processes that make up a firm’s ability to utilize externally held knowledge: exploratory, transformative and exploitative learning. Exploratory learning is concerned with recognizing and understanding potentially valuable new outside knowledge, while transformative learning is meant to assimilate this knowledge. Exploitative learning closes the
sequence and uses the assimilated external knowledge to create new knowledge and commercial outputs. In view of this definition’s compatibility with this study’s objective and set-up, we will use the latter definition as the foundation of the external component of absorptive capacity.

The utilization of processes to value, acquire, assimilate and exploit outside knowledge depends on the firm’s possession of valuable internal knowledge and on its knowledge combining and exchanging capabilities. An interesting research avenue for the internal absorptive capacity sphere of our model is therefore to opt for firm capabilities that increase the knowledge diversity among employees, that develop the individual employees’ absorptive capacity and that stimulate the distribution of knowledge among the firm’s employees. Capabilities directed at ensuring knowledge diversity and knowledge sharing among employees can play this role. Studying practices increasing knowledge diversity across and knowledge sharing among individuals helps us to gain insight into how organizational absorptive capacity develops (Cohen & Levinthal, 1990). Knowledge exploitation (the ultimate aim of absorptive capacity) requires the sharing of relevant knowledge among the firm’s members (Spender, 1996). Formal firm policies affect the effectiveness and efficiency of knowledge transfer (Szulanski, 1996). Internal knowledge sharing and flow practices make up an important knowledge coordinating capability (Jansen et al., 2005) that positively affects radical innovation within firms (Thornhill, 2006). The development of new products or services can also benefit from combining existing knowledge with other, diverse stocks of knowledge (Miller, 2004). As such, practices stimulating knowledge diversity among employees also make up a valuable knowledge-related capability.

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Insert Figure 1 about here

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The full research model thus contains exploratory learning, transformative learning, exploitative learning and the firm’s knowledge diversity and sharing capabilities to explain radical product innovation. The model is depicted in Figure 1. Next, we will develop our research hypotheses, represented by the arrows in the research model.

**Exploratory, Transformative and Exploitative Learning and Innovation**

Schumpeter (1934: 65) defines innovation as “carrying out new combinations” of resources. In terms of knowledge, innovation is the result of the combination of existing and/or new knowledge (Kogut & Zander, 1992). Few firms dispose of all knowledge input needed for radical innovation (Almeida et al., 2003). Radical innovation implies operations beyond the scope of the firm’s current knowledge base (Covin et al., 2003). This applies even more to SMEs and to companies in dynamic environments. Small firms are usually more resource-constrained and have a higher risk of becoming confined in one or more competence traps (Liao et al., 2003). In dynamic environments existing competencies don’t last very long and technologies alter very quickly. Firms in such environments are therefore compelled to have a wide range of knowledge domains at their disposal (Tushman & Anderson, 1986). Most companies however (and certainly the smaller ones) must cross their organizational boundaries if they want to avoid experiencing a knowledge deficit. As a result, most firms try to source knowledge externally in order to be able to innovate radically (Almeida et al., 2003; DeCarolis & Deeds, 1999; Grant, 1996). Absorptive capacity is generally expected to increase the firm’s innovation performance (Tsai, 2001). Specifically, the idea that market information gathering, assimilation and exploitation are critical to the development of new products claims a central position in entrepreneurship and innovation literature (Matsuno et al., 2002). This type of intelligence also reduces the risks associated with radical innovation (Dobni & Luffman, 2003), thus increasing the likelihood of successful innovation.
As mentioned, the externally oriented sphere of absorptive capacity is composed of three sequential processes: exploratory, transformative and exploitative learning (Lane et al. 2006). These processes are different but complementary (Zahra & George, 2002). The sequence must be followed in order to be able to gainfully use and exploit external knowledge: exploitative learning builds on transformative learning and transformative learning is preceded by exploratory learning. It is only in the final stage (exploitative learning) that value is created (Almeida et al., 2003). Valuation of, access to and assimilation of external knowledge are not sufficient by themselves. Innovative output demands the application or use of the acquired and assimilated valuable external knowledge (DeCarolis & Deeds, 1999; Todorova & Durisin, 2007). As a result, we expect exploitative learning to be directly positively related to radical product innovation. Exploratory and transformative learning are necessary (and sequenced) preceding learning processes. Hence our first research hypothesis:

Hypothesis 1a: Exploratory learning is positively related to transformative learning.

Hypothesis 1b: Transformative learning is positively related to exploitative learning.

Hypothesis 1c: Exploitative learning is positively related to innovation.

Knowledge Diversity and Sharing Capabilities and Innovation

Product innovation is a function of the firm’s ability to manage, maintain and create knowledge (Cohen & Levinthal, 1990; Smith et al., 2005). It involves connecting previously unconnected ideas and knowledge or recombining previously connected ideas and knowledge in novel ways (Kogut & Zander, 1992; Nahapiet & Ghoshal, 1998). Either way, it builds on knowledge exchange and combination among employees (Kogut & Zander, 1992). When sourcing knowledge, firms often cross their organizational boundaries (cf. supra). However, underutilized yet potentially valuable knowledge within firm boundaries can also be an interesting source of knowledge (Kang et al., 2007). As this type of knowledge barely
deviates from the firm’s core abilities, it is easier for its members to assimilate and exploit (Tushman & Anderson, 1986). Notwithstanding that the linkage of external knowledge with radical innovation is ordinarily seen as stronger (March, 1991), internal knowledge sources too can leave their mark on radical innovation (Almeida et al., 2003).

All knowledge combination and learning takes place in individual human heads (Grant, 1996). An innovation oriented firm therefore needs practices and capabilities that incite and support the creation, assimilation and exploitation of firm-specific knowledge based by its human resources. Specific capabilities can fulfill this role (Collins & Smith, 2006; Hayton, 2005; Kang et al., 2007). Collins and Smith (2006), for instance, have demonstrated that HR practices affect knowledge exchange and combination through the installation of a social climate characterized by trust, cooperation and shared language. Hayton (2005) and Kang et al. (2007) also acknowledged that HRM can enhance an organization’s social context for learning. Next to this more contextual role of HR practices for organizational learning, we put forward two more direct contributions of specific types of knowledge related capabilities. First, Utterback (1971), Mumford (2000) and Taylor and Greve (2006) noted in their research on innovation and creativity that diversity in the work setting stimulates the creation of new ideas and knowledge. Van den Bosch et al. (1999) pointed to the importance for radical innovation of a broad range of knowledge domains and of practices and abilities that further increase that breadth. As such, practices aiming at stimulating knowledge diversity among the firm’s employees can be of great importance. The likelihood of cognitive conflict (leading to more productive exchanges and greater attempts to combine information and knowledge) increases when employees hold heterogeneous information (Smith et al., 2005). Hence:

*Hypothesis 2: Capabilities increasing knowledge diversity are positively related to innovation.*
Second, organizational knowledge creation and combination (and therefore also innovation) are dependent on the exchange of knowledge among employees. Increased knowledge diffusion through, for example, job rotation and other forms of knowledge diffusion are expected to contribute positively to the firm’s innovative performance (Cohen & Levinthal, 1990; Laursen & Foss, 2003). As firms face a heterogeneous supply of human resources reflecting differences in the distribution of knowledge, skills and abilities across individuals (Wright & Snell, 1991), practices stimulating knowledge sharing are even more important. In fact, it has been argued that such capabilities play a pivotal role in facilitating knowledge flows and organizational learning (Kang et al., 2007). Knowledge transfer stimulating practices help build social linkages among employees and improve individuals’ opportunity, motivation and ability to access each others’ knowledge (Nahapiet & Ghoshal, 1998). Although knowledge is expected to flow more smoothly within SMEs than within large companies, SMEs do not reach the point that knowledge sharing occurs naturally by accident. Supportive action is needed (Shadur & Snell, 2002). Hence:

Hypothesis 3: Capabilities stimulating knowledge sharing are positively related to innovation.

Knowledge Diversity and Sharing Capabilities and the Learning Processes

Cohen and Levinthal (1990) noted that a firm’s absorptive capacity does not simply depend on its interface with the external environment, but also on the transfer of knowledge within the firm’s boundaries and on the character and distribution (diversity) of expertise within the firm. HRM and other internal knowledge related capabilities enable the firm to share, communicate and transfer individual-level learning to the organizational level (Lane et al., 2006). This suggest a linkage between knowledge diversity and sharing practices on one side
and the three learning processes on the other, in the sense that the knowledge related capabilities stimulate the firm’s exploratory, transformative and exploitative learning.

Exploratory learning is expected to be stimulated by knowledge diversity increasing and knowledge sharing facilitating practices. Broadening the employees’ knowledge base enables them to more thoroughly understand and value external knowledge (Collins & Smith, 2005; Miller et al., 2007). A broad knowledge base allows broad scanning and exploring activities. In addition, a more diverse internal knowledge base makes it more interesting for external parties to share knowledge (Almeida et al., 2003). Sharing knowledge among employees gives them a better perspective of how their activities relate to the firm’s value chain (Brown & Duguid, 2001) and can be helpful in the valuation process of external knowledge. Also, practices supporting knowledge transfer within the firm gives the employees experience in transferring knowledge as such, including transfers across the firm’s boundaries. Hence:

*Hypothesis 4: Capabilities (a) increasing knowledge diversity and (b) stimulating knowledge sharing are positively related to exploratory learning.*

As with exploratory learning, transformative learning benefits from knowledge diversity and sharing practices. Broadening employees’ knowledge bases through practices increasing knowledge diversity can help to expand their mental models through lateral interaction (Kang et al., 2007; Wright & Snell, 1991), thus facilitating knowledge assimilation and transformative learning. Knowledge sharing among employees can also stimulate the broadening of mental models and the transmission of routines and schemes for combining knowledge components (Jansen et al., 2005). Knowledge transfer stimulating practices promote the firm’s employees’ ability to interpret issues and build understanding about new external knowledge (Daft & Lengel, 1986). If the firm succeeds in doing so, broader mental models result from it and transformative learning is facilitated. Hence:
Hypothesis 5: Capabilities (a) increasing knowledge diversity and (b) stimulating knowledge sharing are positively related to transformative learning.

Effective development and commercialization (exploitative learning) of radically new products depends on the company’s abilities to delink existing knowledge combinations and relink them in novel ways or combine them with new (often external) knowledge (Danneels, 2002). Practices broadening the employees’ knowledge base enhance exploitative learning. Broader knowledge bases within the firm equal more diverse components of knowledge (including the employees’ mental models) that can be recombined and integrated in new ways (Kang et al., 2007; Miller, 2004). This combinative capability requires the transfer of knowledge (Almeida et al., 2003). As such, capabilities stimulating knowledge sharing among employees are likely to also be positively connected to exploitative learning (Jansen et al., 2005). Hence:

Hypothesis 6: Capabilities (a) increasing knowledge diversity and (b) stimulating knowledge sharing are positively related to exploitative learning.

METHODOLOGY

Data and Sample
The data sample for this study forms a subset of the PASO 2004 survey data. An economy-wide and stratified random survey sample was chosen, with industry and size as stratification variables. It covered all sectors of the Belgian economy, including public and non-profit organizations such as schools, hospitals, et cetera. A minimum size limit of one employee at establishment level was the only inclusion criterion applied. PASO 2004 aimed at contacting the firm’s CEO or the organization’s chief responsible. The PASO 2004 survey’s content
topics were innovation and corporate entrepreneurship. The general response rate for the PASO 2004 survey was 21.36%.

This study’s subset of the PASO 2004 database has been delineated as follows. First, in view of this study’s focus on companies, we eliminated all non-profit organizations. Second, we focused on specific economic sectors for which product/service innovation is relevant: industry, construction, transport, communication and services. We thus eliminated ‘intermediary’ economic sectors such as retail and wholesale. Third, in line with this study’s focus on SMEs we selected those firms that employ at most 250 employees. This demarcation is based on the European Commission’s definition of an SME (which applies to Belgium). Finally, as absorptive capacity is a construct of particular relevance for firms in dynamic environments, we limited the data sample to firms that perceive their environment as dynamic. This was accomplished by means of a median split of the sample on a factor (Cronbach’s alpha 0.88) reflecting the perception of the presence of technological opportunities in the environment and the importance of new products. All items of this environmental dynamism factor are based on Zahra (1993). The upper half of the median-split sample was retained for the analyses. The full data method was used in this study, implying that only cases with data on all variables studied were retained for the analyses, leading to a final sample of 194 SMEs.

**Measures**

**Innovation.** Our innovation measure is based on two specific types of (radical) innovation listed by Schumpeter (1961): (1) the development of a new good not familiar to customers and (2) the development of a new quality (here: radically altered) of a good. Innovation was measured by means of the percentage of sales derived from newly developed or radically altered products or services (in the year 2003). We transformed this percentage by taking the
natural logarithm in order to obtain a normal distribution. This measure has the advantage of being commensurable between industries (Souitaris, 2002). Moreover, it recognizes the radically new nature of the product(s)/service(s) and of its (their) economic significance. It thus reflects the degree to which firms have been able to create new knowledge and exploit it by means of their output market operations.

**Externally Oriented Learning Processes.** Researchers have very often operationalized absorptive capacity as R&D intensity, thus limiting the generalizability of their findings and impeding the progress of absorptive capacity research as a whole (Lane et al., 2006). Additionally, a one-dimensional measure such as R&D intensity does not always capture the multidimensionality of the construct (Liao et al., 2003). In this study, we move away from R&D based absorptive capacity measures. We measure absorptive capacity through three multi-item dimensions referring to the (1) search for and recognition of valuable new external knowledge (exploratory learning), (2) its assimilation and (3) its application in commercial actions. Market knowledge is chosen as specific type of new external knowledge studied. Market knowledge is valuable to all firms, and even more to SMEs. After all, SMEs aim to be more market oriented and they are able to respond to it with alacrity because of the centralization of the decision process with the owner-manager and their non-bureaucratic nature (Carson et al., 1995; Liao et al., 2003). However, whereas large firms have the resources to conduct wide-scale scanning and monitoring of their operating environment, SMEs often have to rely on customers as a source of market intelligence to identify new opportunities (Keh et al., 2006). Market intelligence not only leads to adaptation to current customer needs but also to understanding of and response to customers’ latent and future needs (Slater & Narver, 1998; Verhees and Meulenberg, 2004). This market-oriented approach to measuring absorptive capacity has been taken before (Jansen et al., 2005; Liao et al., 2003). In view of using the market intelligence process as a measure for the externally
oriented absorptive capacity component, all three dimensions are developed to capture the intensity to which market intelligence is undertaken. The scales used to measure market-based exploratory, transformative and exploitative learning are adapted from Kohli et al. (1993). All scales range from 0 to 10 and are calculated following Maes et al. (2005). Annex 1 lists the scales, the corresponding items and the Cronbach’s alphas. All scales comply with the threshold of 0.60 deemed necessary for exploratory research (Hair et al., 1998).

**Knowledge Diversity and Sharing Capabilities.** The intensity of knowledge diversity and knowledge sharing increasing capabilities is measured by means of two indexes, as suggested by Sels et al. (2006). An additive index is most likely to accurately capture the influence of capabilities on diverse firm performance outcomes, including innovation. Both indexes consist in the sum of seven dichotomous variables reflecting the presence (1) or absence (0) of knowledge diversity and knowledge sharing increasing practices. The practices concerned are based on the work of Mumford (2000), Shadur and Snell (2002) and Laursen and Foss (2003). Annex 1 lists the indexes and the corresponding practices. Both index scores range from 0 to 7 and indicate the SMEs’ extent of knowledge diversity/sharing capabilities.

**Control variables.** The analyses have been controlled for industry, company age (number of years) and size (number of employees) to rule out rival hypotheses. Size matters because firms may be more able to innovate radically when they possess more and greater resources (Dewar & Dutton, 1986). We also controlled for firm age because younger SMEs often are more innovative in spite of less well developed capabilities (Baldwin & Gellatly, 2003; Maes, 2006). In order to obtain a normal distribution we have transformed the company size and age measures by taking the natural logarithm. Finally, firms in our sample belong to one of four different economic sectors facing different market conditions. Controlling for industry was therefore necessary. Industry was measured by means of four sector dummies and industry
effects were controlled for by means of effects coding. We included three dummy variables, with manufacturing serving as the point of reference (omitted dummy).

**Methods**

The model depicted in Figure 1 is in fact a mediated model. Mediation is a specific operationalization of fit among variables and tests the specified existence of an important intervening mechanism between an independent and the dependent variable (Venkatraman, 1989). Mediation represents the generative mechanism through which the independent (antecedent) variable affects the dependent variable of interest (Baron & Kenny, 1986). Technically, it decomposes the effects independent and mediating variables have on the dependent variable(s) into direct and indirect effects (Edelman et al., 2005; Venkatraman, 1989). In doing so, it reveals *why* and *how* certain events occur. As such, it fits the study’s objective as it clarifies how knowledge-related capabilities and the three externally oriented learning processes affect the radical product innovation (direct/indirect). And it enables a more accurate estimation of the capabilities’ contribution to innovation. Tests of fit as mediation usually are carried out within a path-analytical framework (Duncan, 1972). In this study this was executed by means of the CALIS procedure in the SAS software.

**RESULTS**

Table 1 presents the means, standard deviations and correlations among the study’s variables. Following Hair et al. (1998), we examined the correlation matrix to identify high correlations (generally 0.90 and above) in order to check for the presence of multicollinearity among the variables. No such high correlations are present, just as no correlations exceed 0.80 (such correlations are indicative of possible multicollinearity problems).
The results of the path analysis (standardized path coefficients) are depicted in Table 2. All goodness-of-fit measures (see Table 2) indicate that the model is supported by the data (Hair et al., 1998; Hatcher, 1994). In path models the endogenous variables are either directly or indirectly affected by other variables. The total effects reflect the full influence of one variable on another. As a result, it is necessary to consider the total effects (sum of direct and indirect effects) in order to accept or reject the research hypotheses. The indirect and total effects are calculated on the basis of the significant (0.10 level or stronger) standardized path coefficients (direct effects). We followed the approach outlined by Sharma (1996) in computing the indirect and total effects. All effects are reported in Table 3.

Before examining linkages with innovation we focus on the relationship between the knowledge-related capabilities and the three learning processes. Hypotheses 4, 5 and 6 propose that capabilities increasing knowledge diversity and knowledge sharing are positively related to each of the three dimensions of externally oriented absorptive capacity: exploratory, transformative and exploitative learning. Reviewing the corresponding total effects in Table 3, these hypotheses receive full support as far as knowledge sharing practices are concerned (hypotheses 4b, 5b and 6b). When it comes to practices directed at increasing knowledge diversity among the firm’s employees, support is partial. Such capabilities are positively
related to exploitative learning (hypothesis 6a), but not to exploratory and transformative learning. Hypotheses 4a and 5a are therefore rejected. Thus, knowledge diversity increasing capabilities only stimulate the use of externally acquired and assimilated knowledge, whereas capabilities increasing knowledge sharing trigger the recognition and understanding of new external knowledge (exploratory learning), its assimilation (transformative learning) and its use (exploitative learning). In the case of transformative learning, however, the effect is purely indirect (via exploratory learning). The effect of knowledge sharing practices is the strongest (and purely direct) as far as exploratory learning is concerned.

Hypothesis 1 draws the linkage between the externally oriented component of absorptive capacity and innovation. It posits that its three learning processes form a sequence and that the last process (exploitative learning) is directly positively associated with radical product innovation. As far as the sequence is concerned, hypothesis 1 is fully supported. Exploratory learning is positively linked with transformative learning (hypothesis 1a) and transformative learning in its turn relates positively to exploitative learning (hypothesis 1b). Further, the association of exploitative learning with innovation is strong and positive, as claimed by hypothesis 1c. All in all, hypothesis 1 receives full support. The development and commercialization of radically new products benefits from the use and application of new external knowledge that has previously (and in that order) been valued, acquired and assimilated.

Taking into account the above results, we can move on to examine the linkages between the knowledge related capabilities and innovation. Taking into account our earlier findings concerning hypotheses 4 to 6, it is possible for the knowledge related capabilities to display direct and indirect effects on innovation. As such, acceptance or rejection of hypotheses 2 and 3 depends on the total effects of knowledge diversity and sharing practices on innovation. The right-hand column of Table 3 supports the conclusion that both types of capabilities are
positively associated with innovation. Hypotheses 2 and 3 therefore receive support. As far as hypothesis 2 is concerned, the support is very strong. Practices aiming to increase knowledge diversity among the SME’s employees are strongly and directly positively associated with innovation. Additionally, they have a small indirect effect (via exploitative learning). Thus, knowledge diversity increasing practices are by themselves a wellspring of radical innovation. And they stimulate the use of acquired and assimilated valuable external knowledge, i.e. exploitative learning. Hypothesis 3 is also supported, albeit that the total positive effect of knowledge sharing enhancing practices is small and fully due to indirect effects via the learning processes. So, knowledge sharing capabilities are worthwhile in terms of radical product innovation, yet these practices – running counter to widespread beliefs - do not serve as a direct wellspring of innovation.

**DISCUSSION AND CONCLUSION**

The objective of this study was to renew the attention for the conceptual and empirical importance of internal knowledge-related processes and capabilities for firm absorptive capacity, next to its externally oriented sphere. Very few empirical contributions have considered both spheres, hereby disregarding to the seminal work of Cohen and Levinthal (1990). Most research has zoomed in on the advantages of absorptive capacity as accessing, assimilating and exploiting knowledge from outside the firm. The few contributions that have considered both spheres of absorptive capacity did not always draw specific linkages between both (e.g. Liao et al., 2003). In this study we aimed to shed some light on how absorptive capacity works in practice by connecting between internally and externally oriented knowledge-related practices of the firm.
Our study contributes to research on absorptive capacity in several ways. Based on Cohen and Levinthal’s (1990) original assumptions, we built our case that absorptive capacity does not reside in the firm alone but also in its employees. By seeing absorptive capacity not only as a function of corporate characteristics but also of processes directed at the individual employees’ absorptive capacity we recognized absorptive capacity as a multi-faceted construct (albeit operationalized at the firm level only). The latter processes were sought in the knowledge-related capabilities sphere. The increased attention for the role of individual employees manifested itself in two ways in this study. We pointed to the role of internal knowledge-related practices to increase individuals’ absorptive capacity, and therefore indirectly the firm’s ability to gain access to and exploit new outside knowledge through innovative products. Further, we also focused on the direct role of firm practices increasing individuals’ knowledge for the product innovation process.

In general, our results corroborate the idea that the learning processes of the externally oriented absorptive capacity sphere are dependent on firms’ capabilities increasing knowledge diversity and sharing among the employees. When it comes to the specific linkages between the capabilities and the learning processes, our results reveal the following. Whereas knowledge diversity practices only link to exploitative learning, knowledge sharing capabilities seem to connect to all three learning processes. In other words, different types of knowledge related capabilities affect the externally oriented learning processes differently, as demonstrated earlier by Jansen et al. (2005). Their findings indicate that coordination capabilities (cross-functional interfaces, job rotation, etc.) primarily enhance acquisition and assimilation of external knowledge (or as they call it: potential absorptive capacity) whereas socialization capabilities (increasing connectedness) primarily strengthen exploitation (realized absorptive capacity). A possible explanation for the finding that practices aimed at increasing knowledge diversity only affect the exploitation of and not gaining access to and
assimilating valuable external knowledge is the SME particularity. In SMEs the owner-manager (or the top management team) often claims exclusivity when it comes to strategic activities such as interacting and negotiating with customers, suppliers and so on (Verhees & Meulenberg, 2004; Smeltzer et al., 1988). And he or she determines whether or not this knowledge is valuable for the small firm vis-à-vis the firm’s existing knowledge base. As such, practices creating knowledge diversity among employees yield no results as far as explorative and transformative learning are concerned. It is only when the acquired and assimilated outside knowledge has to be exploited and used through (e.g.) radical new product development that knowledge diversity among employees comes into play. Future research could therefore examine whether or not this observation also holds in view of power relationships within large companies. Equally interesting could be to investigate the role of knowledge diversity increasing practices for incremental product innovation or for process innovation. It could be that in those cases knowledge diversity among employees also lacks effect on exploitative learning as less distant knowledge domains have to be bridged.

As far as knowledge diversity and sharing capabilities as potential wellsprings of radical innovation are concerned, we observe a very strong direct influence of knowledge diversity stimulating HR practices. This finding points to the importance of internal knowledge diversity for radical innovation in SMEs, a traditional way for small firms to construct a knowledge base (Major & Cordey-Hayes, 2003). However, it is questionable that taking the internal path suffices for SMEs to be successful in radical product innovation (cf. supra). The absorptive capacity component directed at accessing, assimilating and exploiting outside knowledge also leaves a strong mark on radical product innovation. Future research could therefore compare the radical innovation performance of SMEs that develop a purely internal path with those that opt for a purely external path or for a combination of both. Or it could
investigate the interaction (‘when’) between the acquisition, assimilation and use of outside knowledge and the strength of internal knowledge-related practices.

Our study further contributes to absorptive capacity research by developing a process-oriented (capability) view on absorptive capacity. The externally oriented sphere of absorptive capacity has been measured in terms of the firm’s ability to access, assimilate and exploit outside knowledge. This study thus distinguishes itself from the bulk of empirical research that has operationalized absorptive capacity as R&D intensity and patents. Further, given the explicit specification of mechanisms for assimilating and exploiting loosely related knowledge domains, our study has been able to examine the link between radical innovation and absorptive capacity, an area scarcely investigated (Lane et al., 2006). And finally, studying absorptive capacity in SMEs also proved to be worthwhile because it offered the opportunity to make way with two biases. Smaller firms mostly display a traditionally strong knowledge bias on the internal side of the firm in spite of their high need for outside knowledge. And absorptive capacity research is biased towards purely external knowledge, often disregarding what happens inside the firm.

Aside from the aforementioned contributions this study also has a number of limitations that must be addressed. First, our data were self-reported survey data, obtained from a single respondent (the firm’s CEO). However, we remain confident that this concern is minor in view of this study’s SME context. After all, top executives are the best knowledgeable source of firm-level information (Norburn & Birley, 1988). For some types of information (e.g. strategic or other process information) chief executive officers may be the only viable source (Cycyota & Harrison, 2006). We believe both these arguments to hold even stronger when SMEs are concerned in view of upper echelon theory (Hambrick & Mason, 1984).
Second, in this study we focused on firms perceiving their environment as dynamic, i.e. rich in opportunities for innovation and characterized by a high demand for new products. Although the existence of (potentially) valuable outside knowledge in such dynamic environments is obvious, we must recognize that the mere existence of valuable external knowledge is not a sufficient condition for a firm to develop absorptive capacity (Lane et al., 2006). Firms must decide how much to invest in developing absorptive capacity and choose what types of knowledge to focus on. This holds even stronger when radical innovation is concerned, as this type of innovation is more resource consuming and entails higher risks. In an explicit form such choices can be found in competitive strategies and strategic orientations (March, 1991). Future research should therefore take into account the firm’s strategic orientation to get a more accurate view on contribution of absorptive capacity to innovation.

Third, our data is also of a cross-sectional nature, building on various economic sectors. Although this variance in economic background has the advantage of greater generalizability, it entails the danger of missing out on sector-specific mechanisms to develop absorptive capacity. Our cross-sectional nature data also does not allow us to establish strong causality relationships. Absorptive capacity can drive innovation, but in theory the reverse is also possible. As such, longitudinal research is welcome to track firms’ path dependent choices. For instance, this study does not take into account the SME’s previous track record with regard to innovation. As such, we miss out on interesting information as previous innovation points to possessing prior knowledge that could be relevant for the firm’s future innovation process and could color the firm’s development of absorptive capacity.

To conclude, we offer two additional suggestions for future research. First, future research should pay close attention to the role of the power relationships within and around the firms investigated. Powerful actors within and outside the firm may influence knowledge absorption
processes to achieve their goals (Todorova & Durisin, 2007). SMEs form an interesting research population from both perspectives. Internally, the power structure of SMEs is strongly influenced by the firm’s upper echelon. This upper echelon often functions as the firm’s interface with the external environment and it affects the application of the newly acquired outside knowledge. After all, the application of new knowledge must be permitted (Lane et al., 2001) and is dependent on the power-dependent resource allocation process (Noda & Bower, 1996). Externally, due to limited market power, SMEs are highly dependent on their set of customers. Despite the existence of new knowledge, the power of the current customer base can prevent smaller firms from exploiting the new knowledge (Christensen & Bower, 1996). Second, this study has particularly drawn the linkages between internally and externally oriented absorptive capacity, measured thorough knowledge diversity and sharing capabilities and market knowledge related practices. Without doubting the appropriateness of this approach for our research model and set-up, we do not want to give the impression that these choices are universalistically sanctifying. In fact, we would like to see research emerging that explores different operationalizations of the absorptive capacity construct. After all, the dimensions of absorptive capacity remain difficult to measure (Jansen et al., 2005) and its full complexity remains to be further uncovered.
REFERENCES


FIGURE 1
Research Model

Exploratory learning  

Transformative learning  

Exploitative learning  

Knowledge diversity capability  

Knowledge sharing capability  

Radical product innovation
<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
<th>(8)</th>
<th>(9)</th>
<th>(10)</th>
<th>(11)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Innovation (ln) (***)</td>
<td>1.56</td>
<td>1.59</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(2) Exploratory l.</td>
<td>5.16</td>
<td>1.94</td>
<td>0.29</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(3) Transformative l.</td>
<td>5.46</td>
<td>1.97</td>
<td>0.10</td>
<td>0.65</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(4) Exploitative l.</td>
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<td>0.28</td>
<td>0.70</td>
<td>0.54</td>
<td></td>
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<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>(5) Knowledge diversity p.</td>
<td>2.75</td>
<td>2.33</td>
<td>0.33</td>
<td>0.27</td>
<td>0.23</td>
<td>0.43</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(6) Knowledge sharing p.</td>
<td>2.70</td>
<td>2.47</td>
<td>0.30</td>
<td>0.35</td>
<td>0.30</td>
<td>0.47</td>
<td>0.76</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>(7) Company size (ln)</td>
<td>2.85</td>
<td>1.45</td>
<td>0.24</td>
<td>0.27</td>
<td>0.16</td>
<td>0.33</td>
<td>0.36</td>
<td>0.41</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(8) Company age (ln)</td>
<td>2.54</td>
<td>0.94</td>
<td>-0.00</td>
<td>0.00</td>
<td>0.04</td>
<td>0.03</td>
<td>-0.05</td>
<td>-0.03</td>
<td>0.20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(9) Manufacturing</td>
<td>0.39</td>
<td>0.49</td>
<td>0.09</td>
<td>0.28</td>
<td>0.17</td>
<td>0.18</td>
<td>-0.05</td>
<td>-0.06</td>
<td>0.35</td>
<td>0.10</td>
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<tr>
<td>(10) Construction</td>
<td>0.19</td>
<td>0.39</td>
<td>-0.26</td>
<td>-0.26</td>
<td>-0.11</td>
<td>-0.14</td>
<td>-0.12</td>
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<td>-0.29</td>
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<td>(11) Transport &amp; commun.</td>
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<td>0.35</td>
<td>-0.01</td>
<td>-0.16</td>
<td>-0.14</td>
<td>-0.21</td>
<td>-0.06</td>
<td>-0.09</td>
<td>0.08</td>
<td>0.05</td>
<td>-0.32</td>
<td>-0.19</td>
<td></td>
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<tr>
<td>(12) Services</td>
<td>0.28</td>
<td>0.45</td>
<td>0.13</td>
<td>0.05</td>
<td>0.02</td>
<td>0.08</td>
<td>0.20</td>
<td>0.31</td>
<td>-0.19</td>
<td>-0.24</td>
<td>-0.51</td>
<td>-0.30</td>
<td>-0.25</td>
</tr>
</tbody>
</table>

N=194

(*) Correlations greater than or equal to 0.15 are significant (p < 0.05)

(**) ‘ln’ means that the natural logarithm was taken
<table>
<thead>
<tr>
<th>Path from … to …</th>
<th>Exploratory learning</th>
<th>Transformative learning</th>
<th>Exploitative learning</th>
<th>Innovation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exploratory learning</td>
<td>/</td>
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<td>/</td>
<td>/</td>
</tr>
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<td>Transformative learning</td>
<td>/</td>
<td>/</td>
<td><strong>0.44</strong>**</td>
<td>/</td>
</tr>
<tr>
<td>Exploitative learning</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td><strong>0.14</strong> *</td>
</tr>
<tr>
<td>Knowledge diversity HR practices</td>
<td>0.02</td>
<td>0.00</td>
<td><strong>0.15</strong> *</td>
<td><strong>0.23</strong> **</td>
</tr>
<tr>
<td>Knowledge sharing HR practices</td>
<td><strong>0.30</strong> ***</td>
<td>0.10</td>
<td><strong>0.15</strong> *</td>
<td>-0.04</td>
</tr>
<tr>
<td>Company size</td>
<td>0.05</td>
<td>-0.04</td>
<td><strong>0.16</strong> **</td>
<td>0.09</td>
</tr>
<tr>
<td>Company age</td>
<td>-0.01</td>
<td>0.02</td>
<td>0.01</td>
<td>-0.01</td>
</tr>
<tr>
<td>Construction</td>
<td><strong>-0.27</strong> ***</td>
<td>0.03</td>
<td>-0.05</td>
<td><strong>-0.17</strong> **</td>
</tr>
<tr>
<td>Transport &amp; communication</td>
<td><strong>-0.22</strong> ***</td>
<td>-0.05</td>
<td><strong>-0.15</strong> ***</td>
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<tr>
<td>Services</td>
<td><strong>-0.17</strong> **</td>
<td>-0.10</td>
<td>-0.02</td>
<td>0.05</td>
</tr>
</tbody>
</table>

* p < 0.10   ** p < 0.05   *** p < 0.01   **** p < 0.001

N=194; Goodness of Fit Index (GFI) 0.95; Bentler’s Comparative Fit Index 0.92; Bentler & Bonett’s NFI 0.92
TABLE 3
Direct, Indirect and Total Effects

<table>
<thead>
<tr>
<th>Effect of … on …</th>
<th>Exploratory learning</th>
<th>Transformative learning</th>
<th>Exploitative learning</th>
<th>Innovation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Direct</td>
<td>Indirect</td>
<td>Total</td>
<td>Direct</td>
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<td>Exploratory learning</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>0.61</td>
</tr>
<tr>
<td>Transformative learning</td>
<td>/</td>
<td>/</td>
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<td>/</td>
</tr>
<tr>
<td>Exploitative learning</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>Knowledge diversity HR</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>Knowledge sharing HR</td>
<td>0.30</td>
<td>/</td>
<td>0.30</td>
<td>/</td>
</tr>
<tr>
<td>Company size</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>Company age</td>
<td>/</td>
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<td>/</td>
</tr>
<tr>
<td>Construction</td>
<td>-0.27</td>
<td>/</td>
<td>-0.27</td>
<td>/</td>
</tr>
<tr>
<td>Transport &amp; communication</td>
<td>-0.22</td>
<td>/</td>
<td>-0.22</td>
<td>/</td>
</tr>
<tr>
<td>Services</td>
<td>-0.17</td>
<td>/</td>
<td>-0.17</td>
<td>/</td>
</tr>
</tbody>
</table>
ANNEX 1

<table>
<thead>
<tr>
<th>Item</th>
<th>Exploratory learning</th>
<th>Transformative learning</th>
<th>Exploitative learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>At least once a year we invite our customers to find out what kind of products/services they will need in the future</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In this firm we invest a lot of time and energy in market research</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In this firm we have very little eye for changes that occur in our customers preferences (reverse-coded)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>We sound out our customers at least once a year with regard to the quality of our products/services</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>We don’t succeed in tracing important changes in our economic sector in a timely fashion (e.g. new competitors, new legislation, new materials, etc.) (reverse-coded)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At least every three months we systematically analyze the trends and developments on our market</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In an important competitor would start an intensive campaign towards our clients, we immediately know how to react</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>When our clients expect us to adapt a product or service we feel capable of doing so in a coordinated manner</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The activities of all our business domains are well integrated</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expected changes in our clients’ needs are regularly discussed with all employees within this firm</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Periodically we analyze our product development efforts to ensure that they comply with our customers’ needs</td>
<td></td>
<td>X</td>
<td></td>
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<tr>
<td>We often organize meetings to determine and plan our response to important changes in the firm’s environment</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Periodically we determine the impact of changes in our firm’s environment on our firm through our customers’ preferences</td>
<td></td>
<td>X</td>
<td></td>
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<tr>
<td>Cronbach’s alpha</td>
<td>0.65</td>
<td>0.60</td>
<td>0.77</td>
</tr>
</tbody>
</table>

Knowledge diversity increasing HR index

- To schedule bootlegging time for employees to experiment and develop new ideas
- Deliberately and purposefully giving challenging assignments in order to increase creativity and learning ability
- Giving training on methods for creative problem solving
- Measuring employee competences to determine specific training and development needs
- Providing financial rewards for obtained new competences or skills
- Setting up systems of job rotation
- Providing training on learning willingness and learning skills

Knowledge sharing simulating HR index

- The use of systems that promote the availability of knowledge to everyone (employee information meetings, newsletters, etc.)
- To set up a formal introduction program for new employees
- To develop career paths across functional boundaries (such as marketing, production, etc.)
- To provide team or group based rewards (e.g. gain sharing, group bonus, etc.)
- Systematically updating databases or inventories with new knowledge
- Stimulating employees to actively add new knowledge to databases or inventories
- Providing unrestricted access to employees to knowledge databases and inventories