Available online at www.sciencedirect.com
ScienceDirect
Technovation 29 (2009) 423–437
technovation
www.elsevier.com/locate/technovation

Open innovation in SMEs: Trends, motives and management challenges

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Abstract

Open innovation has so far been studied mainly in high-tech, multinational enterprises. This exploratory paper investigates if open innovation practices are also applied by small- and medium-sized enterprises (SMEs). Drawing on a database collected from 605 innovative SMEs in the Netherlands, we explore the incidence of and apparent trend towards open innovation. The survey furthermore focuses on the motives and perceived challenges when SMEs adopt open innovation practices. Within the survey, open innovation is measured with eight innovation practices reflecting technology exploration and exploitation in SMEs. We find that the responding SMEs engage in many open innovation practices and have increasingly adopted such practices during the past 7 years. In addition, we find no major differences between manufacturing and services industries, but medium-sized firms are on average more heavily involved in open innovation than their smaller counterparts. We furthermore find that SMEs pursue open innovation primarily for market-related motives such as meeting customer demands, or keeping up with competitors. Their most important challenges relate to organizational and cultural issues as a consequence of dealing with increased external contacts.

Keywords: Open innovation; SMEs; Technology markets; Incidence; Perceived trend; Motives; Managerial challenges

1. Introduction

Open innovation has been proposed as a new paradigm for the management of innovation (Chesbrough, 2003; Gassmann, 2006). It is defined as 'the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and to expand the markets for external use of innovation, respectively.' (Chesbrough et al., 2006, p. 1). It thus comprises both outside-in and inside-out movements of technologies and ideas, also referred to as 'technology acquisition' and 'technology exploitation' (Lichtenthaler, 2008).

Open innovation has received increasingly attention in scientific research, but so far it has mainly been analyzed in large, high-tech multinational enterprises (MNEs) drawing on in-depth interviews and case studies (e.g. Chesbrough, 2003; Kirschbaum, 2005). Few studies have demonstrated that open innovation also exists in smaller organizations. Moreover, all of them focus on very specific industries, for example open source software (Henkel, 2006) or tabletop role-playing games (Lecocq and Demil, 2006). Whenever large samples of enterprises are explored, the focus is on specific issues rather than the full open innovation model (e.g. Laursen and Salter, 2006; Chesbrough, 2002). To our knowledge, only Lichtenthaler (2008) has so far attempted to empirically study the incidence of open innovation in a broader sample of enterprises. He focused on medium-sized and large manufacturers in Germany, Switzerland and Austria, as small enterprises and service industries were not surveyed.

This study addresses this gap by focusing on small- and medium-sized enterprises (SMEs). It is a first, explorative study measuring to which extent SMEs apply open

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doi:10.1016/j.technovation.2008.10.001

innovation practices and whether there is a trend towards increased adoption of the open innovation model over time. In doing so, we develop and test propositions on the differences between manufacturing and services firms, and between medium-sized and small enterprises. Furthermore, we explore the motives of SMEs to engage in open innovation and perceived management challenges in implementing open innovation. To our knowledge this study is the first to investigate the incidence of open innovation in a broad sample of SMEs. In doing so, it assesses whether open innovation is a trend that is not only relevant for high-tech MNEs but also for a broader range of firms and businesses. As we draw on a survey database of 605 SMEs in the Netherlands, the paper also accounts for the potential criticism that open innovation has so far been studied mainly in American enterprises (e.g. Chesbrough, 2003; Chesbrough and Crowther, 2006; Lecocq and Demil, 2006) and not in others parts of the world (a notable exception is Lichtenthaler, 2008).

The remainder of the paper is structured as follows. Section 2 discusses open innovation and the dimensions of technology exploitation and exploration that can be used to classify open innovation practices. Next, we develop some tentative propositions on the adoption of open innovation practices in manufacturing and service firms, and between different size categories of SMEs. Section 4 describes our data, while Section 5 analyses the incidence and trend towards open innovation, and motives and hampering factors of SMEs. Finally, Section 6 concludes and discusses the limitations and implications of our work.

2. Open innovation

Traditionally, large firms relied on internal R&D to create new products. In many industries, large internal R&D labs were a strategic asset and represented a considerable entry barrier for potential rivals. As a result, large firms with extended R&D capabilities and complementary assets could outperform smaller rivals (Teece, 1986). This process in which large firms discover, develop and commercialize technologies internally has been labeled the closed innovation model (Chesbrough, 2003). Although this model worked well for quite some time, the current innovation landscape has changed. Due to labor mobility, abundant venture capital and widely dispersed knowledge across multiple public and private organizations, enterprises can no longer afford to innovate on their own, but rather need to engage in alternative innovation practices. As a result, a growing number of MNEs has moved to an open innovation model in which they employ both internal and external pathways to exploit technologies and, concurrently, to acquire knowledge from external sources (Chesbrough, 2003).

Open innovation is a broad concept encompassing different dimensions. Following the definition mentioned earlier, most studies distinguish between purposive outflows and inflows of knowledge to accelerate internal innovation processes and to better benefit from innovative efforts, respectively (e.g. Chesbrough et al., 2006; Chesbrough and Crowther, 2006). Purposive outflows of knowledge, or *technology exploitation*, implies innovation activities to leverage existing technological capabilities outside the boundaries of the organization. Purposive inflows, which we will refer to as *technology exploration*, relates to innovation activities to capture and benefit from external sources of knowledge to enhance current technological developments. In a fully open setting, firms combine both technology exploitation and technology exploration in order to create maximum value from their technological capabilities or other competencies (Chesbrough and Crowther, 2006; Lichtenthaler, 2008).

2.1. Technology exploitation

In order to better profit from internal knowledge, enterprises may engage in various practices. In this paper, three activities related to technology exploitation will be distinguished: venturing, outward licensing of intellectual property (IP), and the involvement of non-R&D workers in innovation initiatives.

Venturing is defined here as starting up new organizations drawing on internal knowledge, i.e. it implies spin-off and spin-out processes. Support from the parent organization may also include finance, human capital, legal advice, administrative services, etc. Previous open innovation studies have primarily focused on venturing activities in large enterprises (e.g. Chesbrough, 2003; Lord et al., 2002). The potential of venturing activities is regarded to be enormous, e.g. Chesbrough (2003) illustrated that the total market value of 11 projects which turned into new ventures exceeded that of their parent company, Xerox, by a factor of two.

IP plays a crucial role in open innovation as a result of the in- and outflows of knowledge (Arora, 2002; Chesbrough, 2003, 2006; Lichtenthaler, 2007). Enterprises have opportunities to out-license their IP to obtain more value from it (Gassmann, 2006). Out-licensing allows them to profit from their IP when other firms with different business models find profitable, external paths to the market. The decision of firms to license out depends on anticipated revenues and profit-dissipation effects (Arora et al., 2001), i.e. outward licensing generates revenues in the form of licensing payments, but current profits might decrease when licensees use their technology to compete in the same market. Prior research has shown the importance of establishing a reputation as a knowledge provider in order to increase the monetary and strategic benefits of technology out-licensing (Lichtenthaler and Ernst, 2007).

A third practice to benefit from internal knowledge is to capitalize on the initiatives and knowledge of current employees, including those who are not employed at the internal R&D department. Several case studies illustrate that informal ties of employees with employees of other

organizations are crucial to understand how new products are created and commercialized (e.g. Chesbrough et al., 2006). Many practitioners and scientists, also outside the field of open innovation, endorse the view that innovation by individual employees is a means to foster organizational success (e.g. Van de Ven, 1986). Work has become more knowledge-based and less rigidly defined. In this context, employees can be involved in innovation processes in multiple ways, for example by taking up their suggestions, exempting them to take initiatives beyond organizational boundaries, or introducing suggestion schemes such as idea boxes and internal competitions (e.g. Van Dijk and Van den Ende, 2002).

2.2. Technology exploration

Technology exploration refers to those activities which enable enterprises to acquire new knowledge and technologies from the outside. In the survey, five practices were distinguished related to technology exploration: customer involvement, external networking, external participation, outsourcing R&D and inward licensing of IP.

Open innovation theorists recognize that customer involvement is one important alternative to inform internal innovation processes (Gassmann, 2006). Drawing on the work of Von Hippel (2005) users are increasingly regarded not as just passive adopters of innovations, but they may rather develop their own innovations which producers can imitate. Users for example regularly modify their current machines, equipment and software to better satisfy process needs, and because producers fail to provide an adequate supply (Von Hippel, 2005). Firms may benefit from their customers' ideas and innovations by proactive market research, providing tools to experiment with and/or develop products similar to the ones that are currently offered, or by producing products based on the designs of customers and evaluating what may be learned from general product development.

External networking is another important dimension which is consistently associated with open innovation (Chesbrough et al., 2006). It includes all activities to acquire and maintain connections with external sources of social capital, including individuals and organizations. As such, it comprises both formal collaborative projects and more general and informal networking activities. Networks allow enterprises to rapidly fill in specific knowledge needs without having to spend enormous amounts of time and money to develop that knowledge internally or acquire it through vertical integration. Networks may also evolve into formal collaborative efforts such as R&D alliances. Such alliances between non-competing firms have become a popular vehicle for acquiring technological capabilities (Gomes-Casseres, 1997).

External participations enable the recovery of innovations that were initially abandoned or that did not seem promising. Enterprises may invest in start-ups and other businesses to keep an eye on potential opportunities (Chesbrough, 2006; Keil, 2002). Such equity investments provide opportunities to further increase external collaboration in case their technologies prove to be valuable (Van de Vrande et al., 2006). Enterprises may also outsource R&D activities to acquire external knowledge. At the heart of the open paradigm is the assumption that enterprises cannot conduct all R&D activities by themselves, but instead have to capitalize on external knowledge which can be licensed or bought (Gassmann, 2006).

Technical service providers such as engineering firms and high-tech institutions have also become more important in the innovation process. In the open model it is considered fully legitimate to bring key knowledge development outside the organizational boundary (e.g. Prencipe, 2000).

Finally, enterprises can externally acquire intellectual property, including the licensing of patents, copyrights or trade marks, to benefit from external innovation opportunities (Chesbrough, 2006). This may be a necessity to fuel one's business model and to speed up and nurture internal research engines.

To conclude, in comparison with the closed model, the open innovation model implies that the management and organization of innovation processes becomes more complex, i.e. open innovation includes many more activities than just those that were assigned to a traditional R&D department.

3. Innovation in SMEs

Having discussed how open innovation can be defined and operationalized, the current section develops some tentative propositions on the incidence of open innovation in SMEs, what differences can be anticipated between industries and size classes, and what motives and management challenges may be encountered.

3.1. Incidence and trends

In the closed innovation model enterprises must generate their own ideas and then develop, build, market, distribute, and support them on their own. This model counsels enterprises to be strongly self-reliant, implicitly recommending organizing innovation in internal R&D departments. In contrast, the open model prescribes enterprises to draw on both external and internal ideas and paths to the market, when enterprises look to discover and develop innovative opportunities (Chesbrough, 2003). In doing so, the open innovation model recognizes that smaller firms take an increasingly prominent role in the contemporary innovation landscape. Some first tentative evidence is found in Chesbrough (2003) as he cited statistics of how small enterprises contribute to total industrial R&D expenses in the US. They accounted for around 24% of all R&D spending in 2005, compared to only 4% in 1981 (National Science Foundation, 2006). Likewise, in an interview-based study of 12 enterprises in mainly low-tech industries, Chesbrough and Crowther (2006) found that

basically all respondents had to some extent picked up open innovation practices, with a clear focus on technology exploration activities. Another example is Lichtenthaler (2008) who conducted a survey among medium-sized and large manufacturers in Germany, Austria and Switzerland. He found that 32.5% of the respondents was somehow engaged in open innovation.

Besides, there have been multiple studies on the strengths and weaknesses of SMEs in their organization of innovation processes (e.g. Vossen, 1998; Acs and Audretsch, 1990). This work concludes that innovation in SMEs is hampered by lack of financial resources, scant opportunities to recruit specialized workers, and small innovation portfolios so that risks associated with innovation cannot be spread. SMEs need to heavily draw on their networks to find missing innovation resources, and due to their smallness, they will be confronted with the boundaries of their organizations rather sooner than later. In today's increasingly complex and knowledge-intensive world with shortened product life cycles, such networking behavior has become probably even more important than before. Given these considerations, we anticipate that open innovation practices are not exclusively applied by MNEs, but will also be present in SMEs, and will be increasingly adopted.

3.2. Industries and size classes

Prior research gives the impression of industrial differences regarding the incidence of and trend towards open innovation. In the current paper, we explore the differences between manufacturing and services industries. Services differ from physical goods in terms of intangibility, inseparability, heterogeneity and perishability (Atuahene-Gima, 1996). Given the distinct nature of the offerings of manufacturing and services firms, differences in the adoption of open innovation may be very plausible. As physical goods are more separable and homogenous, it is much easier to outsource parts of the R&D process or to in-source new ideas and technologies that fit with current business lines. Gassmann (2006) proposes that industries are more prone to engage in open innovation if they are characterized by globalization, technology intensity, technology fusion, new business models and knowledge leveraging. We argue that especially the first three characteristics as defined by Gassmann (2006) are more applicable to manufacturers than to services enterprises, i.e. manufacturing enterprises generally tend to operate in larger geographical regions and the nature of their processes demands higher investments in capital and technologies. For services—due to their relatively intangible, simultaneous and heterogeneous nature—the opposite applies. Indeed, descriptive statistics of Dutch enterprises offered by Statistics Netherlands (2006) demonstrate that manufacturers are on average more technology-intensive, invest more in R&D, and operate in larger regions. We therefore anticipate that the incidence and adoption of open innovation will be stronger in manufacturing industries.

Besides industry differences, the size of enterprises may also influence the adoption of open innovation. Our survey results contain information on both small enterprises (defined as 10–99 employees) and medium-sized ones (100–499 employees). Past work has shown that there is a great deal of difference in the innovation strategies of small and large firms (e.g. Vossen, 1998; Acs and Audretsch, 1990). Innovation processes of larger firms are typically more structured and professionalized. As SMEs grow they increasingly develop and apply formal structures, also marked by recruiting specialized workers, and introducing managerial layers, rules and procedures (Greiner, 1972). Once a critical size is reached, they may be better able to formalize their innovation practices and to develop structures for licensing IP, venturing activities and external participations. Their larger size also enables them to maintain large and diversified innovation portfolios (to spread risks) and to reserve structural funds to finance innovation. This may have important implications for the application of open innovation in these firms. The extent to which they can engage in technology exploitation and exploration activities is likely to be contingent on their size. As a result, we propose that open innovation is more commonly applied by medium-sized enterprises and that any trend towards open innovation is stronger in this group.

3.3. Motives and challenges

Many firms started to implement open innovation as a necessary organizational adaptation to changes in the environment (Chesbrough, 2003). In a world of mobile workers, abundant venture capital, widely distributed knowledge and reduced product life cycles, most enterprises can no longer afford to innovate on their own. A further exploration of motives was done by Chesbrough and Crowther (2006). In an interview-based study they found that the most common reason for external technology acquisition was a common belief that it is critical to maintain growth. It is anticipated that basic entrepreneurial values such as growth and revenues will be among the key motives of enterprises to practice open innovation. Previous work on motives for open innovation focused on MNEs and usually covered only few open innovation practices. EIRMA (2003) for example showed that R&D managers of large corporations engage in venturing for market-related motives such as meeting customer demands, but also to acquire new knowledge. Likewise, Jacobs and Waalkens (2001) found that organizations 'innovate their innovation processes' to reduce time-to-market and to better utilize internal creativity. Hence, we expect market considerations and knowledge creation to be key motives for open innovation.

Other potential motives can be derived from innovation collaboration studies. This literature suggests that

enterprises may engage in collaboration to acquire missing knowledge, complementary resources or finance, to spread risks, to enlarge its social networks, or to reduce costs (Hoffman and Schlosser, 2001; Mohr and Spekman, 1994). Such motives mainly reflect outside-in considerations while motives to conduct outbound activities seem to be missing. Koruna (2004) however identified various objectives for firms to externally exploit their knowledge, including revenues and access to knowledge, but also to set industry standards, to profit from infringements, to realize learning effects, and to guarantee freedom to operate by establishing cross-licensing agreements with other organizations.

As for the challenges of open innovation in SMEs, our data set contains information on perceived barriers to adopt open innovation practices. The open innovation literature has so far witnessed few attempts to explore this subject. Chesbrough and Crowther (2006) for example identified the not-invented-here (NIH) syndrome and lack of internal commitment as main hampering factors. The NIH syndrome has been previously found to be a prominent barrier for external knowledge acquisition (e.g. Katz and Allen, 1982). Although focused on the external acquisition of knowledge, its underlying antecedents are also applicable to technology exploitation, leading to the 'only-used-here' (OUH) syndrome (Lichtenthaler and Ernst, 2006). More potential barriers can again be found in the related literature on collaborative innovation. Boschma (2005) for example identified various forms of 'proximity' which are essential for effective collaboration. These include cognitive, organizational, cultural and institutional differences between collaboration partners, implying that potential problems may arise due to insufficient knowledge, cultures or modes of organization, or bureaucratic elements. To mention only a few, other potential barriers include lacking resources, free-riding behavior, and problems with contracts (Hoffman and Schlosser, 2001; Mohr and Spekman, 1994).

4. Methods

4.1. Sample

To analyze the trends, motives and management challenges of SMEs with regards to open innovation, we use a survey database that was collected by EIM, a Dutch institute for business and policy research. The survey was commissioned by the Dutch Advisory Council on Science and Technology to support a policy advice on open innovation (see AWT, 2006). The survey targeted SMEs, defined as enterprises with no more than 500 employees, and was implemented by means of computer-assisted telephone interviewing. Data collection was done over a 3-week period in December 2005. To reliably identify trends only respondents with long tenure and representing enterprises that systematically innovate, were selected. The survey therefore started with screening questions. Respondents first indicated if their company had developed at least one innovation in the past 3 years. This could either be a product-, process-, organizational- or marketing-related innovation as defined by the Oslo manual (a set of integral guidelines for the collection of innovation data, see OECD, 2005). Secondly, the survey asked if respondents' enterprises had formulated an innovation strategy. Thirdly, respondents had to be employed in their current jobs for at least 7 years. In this way, the screening ensured that respondents all represented SMEs with systematic innovation efforts, and they were in a position to adequately judge if and how innovation processes had developed over the past 7 years.

The sample was disproportionally stratified across manufacturing and service industries and two size classes (10–99 employees and 100–499 employees). Enterprises with less than 10 employees (micro-enterprises) were excluded since they generally have no or limited identifiable innovation activities, and this population usually contains many start-ups. It was anticipated that very few micro-enterprises would pass the screening. The sample was drawn from the Dutch Chambers of Commerce database. Interviewers explicitly asked for those who were responsible for innovation, i.e. small business owners, general managers, R&D managers or staff managing new business development activities. In total 2230 respondents were contacted, of whom 1206 persons (54%) were willing to participate. To check for non-response bias, respondents and non-respondents were compared across industries and size classes. Contrasting both groups with χ^2-tests revealed no significant differences at the 5% level ($p = 0.23$ for type of industry and $p = 0.55$ for size classes). A total of 605 respondents passed the screening phase, corresponding with a final sampling rate of 27%. Table 1 shows how these respondents are distributed across size classes and industries.

4.2. Variables

The survey proceeded with questions on the nature of firms' innovation processes. More specifically, eight open innovation practices were distinguished, which are defined in Table 2.

After the screening questions, the respondents were asked if their enterprise had engaged in any venturing activities in the past 3 years. Throughout the survey a time space of 3 years was used, resembling the criterion used by Statistics Netherlands to identify innovative enterprises (Statistics Netherlands, 2006; OECD, 2005). Secondly, respondents were asked if venturing activities in their enterprise had increased, remained stable, or had decreased in the past 7 years (if venturing activities were missing the question was rephrased as if venturing had been stable or decreased). Thirdly, in case the firms were involved in open innovation activities, the interviewer asked to provide the motives to do so. Their answers were recorded in an open-ended format. Finally, respondents were asked if they had perceived any barriers to implement open innovation practices, and if so, to describe them.

Table 1
Distribution of respondents across industries and size classes

Type of industry	*Size class*		
	10–99 employees	100–499 employees	Total
Manufacturing			
Food and beverages (NACE codes 15–16)	40	21	
Chemicals, rubber and plastics (NACE codes 23–25)	54	22	
Machinery and equipment (NACE codes 29–34)	19	32	
Other manufacturers (NACE codes 17–22; 26–28; 35–37)	47	53	
	160	128	288
Services			
IT (NACE code 72)	53	17	
Business services (NACE codes 73–74)	59	24	
Other services (NACE codes 50–71; 93)	104	60	
	216	101	317
Total	376	229	605

Table 2
Surveyed open innovation practices

Practice	Definition
Technology exploitation	
Venturing	Starting up new organizations drawing on internal knowledge, and possibly also with finance, human capital and other support services from your enterprise.
Outward IP licensing	Selling or offering licenses or royalty agreements to other organizations to better profit from your intellectual property, such as patents, copyrights or trade marks.
Employee involvement	Leveraging the knowledge and initiatives of employees who are not involved in R&D, for example by taking up suggestions, exempting them to implement ideas, or creating autonomous teams to realize innovations.
Technology exploration	
Customer involvement	Directly involving customers in your innovation processes, for example by active market research to check their needs, or by developing products based on customers' specifications or modifications of products similar like yours.
External networking	Drawing on or collaborating with external network partners to support innovation processes, for example for external knowledge or human capital.
External participation	Equity investments in new or established enterprises in order to gain access to their knowledge or to obtain others synergies.
Outsourcing R&D	Buying R&D services from other organizations, such as universities, public research organizations, commercial engineers or suppliers.
Inward IP licensing	Buying or using intellectual property, such as patents, copyrights or trade marks, of other organizations to benefit from external knowledge.

The other innovation practices were surveyed with an identical sequence of questions. The only exception was the innovation practice of outward IP licensing. Here, the sequence was preceded by a screening question checking whether the firm actually possessed any IP.

During the third and fourth part of the survey, respondents were asked to clarify their motives when they get involved in the different 'open innovation' practices. The various answers of the respondents to the question what drives them to get involved in open innovation practices were coded, resulting in the categories described in Table 7. A similar approach was adopted for the perceived barriers to adapt open innovation. This resulted in elf types of barriers described in Table 8. The coding process was organized with two researchers. They first read all open-ended answers and together identified a number of preliminary categories. Next, they carefully studied all answers and classified them into the scheme. New categories could be proposed whenever they felt that the categories were insufficient or should be refined. Finally, all classifications were compared and different opinions discussed and resolved. Because only few SMEs possess and trade IP (see Table 3), the data did not contain enough records to provide reliable insights about respondents' motives and challenges on this topic.

5. Results

5.1. Incidence and trends

Table 3 shows the incidence of open innovation practices in our sample of innovative SMEs. The three last columns also give an overview of the evolution of the use of these practices in Dutch innovative SMEs. The table shows the shares of respondents conducting various aspects of technology exploitation and technology exploration, and the extent to which they perceived an increase, stabilization or decrease in the application of these practices in the past 7 years.

Table 3 shows that customer involvement, external networking and employee involvement are fairly common innovation practices. Outward and inward licensing of IP, venturing and external participations in other enterprises are conducted by only by a minority of the respondents, while R&D outsourcing is done by half of the sample.

The table also shows that for every surveyed practice, the share of respondents perceiving an increase over the past 7 years is substantially larger than the share with a decrease. These results suggest that open innovation is not just conducted by MNEs, but rather also applies to a broad sample of SMEs, and moreover, open innovation is on average increasingly adopted.

5.2. Industries and size classes

Table 4 compares the incidence and trend towards open innovation between manufacturing and services enterprises. For ease of presentation, trend scores have been averaged. We applied various tests to analyze significant differences. As *t*-test procedures were less suitable because most dependent variables violated the required normal distribution, Table 4 reports non-parametric Mann–Whitney tests on significant median differences. We did routinely check if our results were robust for the chosen test. It appeared that χ^2- and independent samples *t*-tests produced nearly identical results. Besides, as Dutch manufacturers tend to be relatively large organizations (Bangma, 2005), we also ran multivariate analysis of variance models in which size classes were entered as control variables. Again, significances of the differences between manufacturing and services were nearly identical (output available on request).

The left-hand side of Table 4 shows only few significant differences between manufacturing and services enterprises. Employee involvement, customer involvement and external networking appear to be main types of open innovation conducted by both manufacturers and services enterprises. We do remark that these practices were defined very broadly (Table 2) and hence may blur any significant difference (also see discussion section). Nevertheless, the other indicators reveal no systematic pattern of differences between industries. In manufacturing there seems to be somewhat more attention for technology exploration, i.e. manufacturers relatively often engage in R&D outsourcing and inward IP licensing. In contrast, services enterprises do better on venturing activities (33% versus 24%, $p<0.05$). The right-hand side of Table 4 reveals that the trend towards open innovation is observed in both industries, i.e. average trend scores are consistently positive. We again find only few significant differences. Manufacturers have adopted R&D outsourcing more often (0.23 versus 0.13, $p<0.01$) while the opposite applies to venturing activities. In a recent survey of manufacturers, Lichtenthaler (2008) analyzed industry differences in more detail and also found no significant differences. In all, we do not find major differences between the manufacturing and services industries with regards to the incidence and trend towards open innovation practices.

Table 5 provides similar output for the differences between small- and medium-sized enterprises. Again, significances were analyzed with different tests (including multivariate analysis of variance with industry controls) and proved to be robust.

Table 3
Incidence and perceived trends in open innovation practices ($n = 605$)

	Incidence (%)	Perceived trend		
		Increase (%)	Stable (%)	Decrease (%)
Technology exploitation				
Venturing	29	14	84	2
Outward IP licensing	10	4	95	1
Employee involvement	93	42	57	1
Technology exploration				
Customer involvement	97	38	61	1
External networking	94	29	67	4
External participation	32	16	83	1
Outsourcing R&D	50	22	73	5
Inward IP licensing	20	5	93	2

Table 4
Incidence of and perceived trends in open innovation practices between industries

	Incidence			Perceived trend[a]		
	Manufacturing ($n = 288$) (%)	Services ($n = 317$) (%)	Mann–Whitney $Z(U)$	Manufacturing ($n = 288$)	Services ($n = 317$)	Mann–Whitney $Z(U)$
Technology exploitation						
Venturing	24	33	2.4^	0.09	0.15	2.1^
Outward IP licensing	11	8	1.2	0.02	0.02	0.1
Employee involvement	94	93	0.7	0.41	0.41	0.2
Technology exploration						
Customer involvement	98	97	0.8	0.34	0.40	1.3
External networking	95	94	0.6	0.24	0.26	0.4
External participation	29	34	1.2	0.14	0.15	0.3
Outsourcing R&D	59	43	4.0**	0.23	0.13	2.6*
Inward IP licensing	25	15	3.2*	0.04	0.03	0.6

**$p<0.001$, *$p<0.01$, ^$p<0.05$.
[a]Average score with increase coded 1, stable coded 0 and decrease coded −1.

Table 5
Incidence of and perceived trends in open innovation practices between size classes

	Incidence			Perceived trend[a]		
	10–99 employees ($n = 376$) (%)	100–499 employees ($n = 229$) (%)	Mann–Whitney $Z(U)$	10–99 employees ($n = 376$)	100–499 employees ($n = 229$)	Mann–Whitney $Z(U)$
Technology exploitation						
Venturing	27	32	1.4	0.11	0.14	1.2
Outward IP licensing	6	16	4.3**	0.01	0.04	1.5
Employee involvement	92	96	1.7	0.37	0.48	2.8*
Technology exploration						
Customer involvement	97	98	1.1	0.30	0.50	4.6**
External networking	94	95	0.4	0.20	0.33	3.2*
External participation	24	44	5.2**	0.13	0.18	2.0^
Outsourcing R&D	42	64	5.1**	0.14	0.24	2.5^
Inward IP licensing	14	29	4.7**	0.02	0.07	2.2^

**$p<0.001$, *$p<0.01$, ^$p<0.05$.
[a]Average score with increase coded 1, stable coded 0 and decrease coded −1.

Table 5 shows that medium-sized enterprises (100–499 employees) are more likely to engage in open innovation. On all technology exploitation and exploration practices they are doing slightly or substantially better. Bearing in mind that employee involvement, customer involvement and external networking were broadly defined, the differences between both size classes are not significant. As for perceived trends, the right-hand side of Table 5 shows substantial differences. All values in the column of respondents with 100–499 employees are (much) larger. Especially for the technology exploration activities medium-sized enterprises are much more involved in these open innovation activities. This result contrasts the findings by Lichtenthaler (2008), who concluded that firm size did not have a major impact on the degree of technology exploration, but it did influence technology exploitation. In sum, we find that medium-sized enterprises apply and adopt open innovation more often than their smaller counterparts, as expected.

5.3. Cluster analysis

To explore the incidence of open innovation in more detail, we decided to cluster the respondents in groups of SMEs that are homogenous in their open innovation strategy and organization of innovation practices (see also Lichtenthaler (2008) for a similar approach). The analysis was based on the eight dichotomous variables measuring the incidence of technology exploitation and exploration practices. We started the analysis with a principal component analysis (PCA) to reduce the number of dimensions in our data and applied cluster analytic techniques to find homogeneous groups of enterprises. Finally, the differences between clusters were explored with non-parametric tests.

PCA summarizes the variance of a set of variables in a limited number of components. This provides uncorrelated component scores at the interval level which are more suitable for cluster procedures, and prevents that single variables dominate a cluster solution (Hair et al., 1998). A first exploratory run demonstrated that our data were suitable for PCA (i.e. MSA values all >0.57, KMO measure $= 0.61$ and p(Bartlett)<0.001, see Hair et al., 1998). To determine the number of components we applied the latent root criterion (eigenvalues >1.0). As a result we obtained a three-dimensional solution explaining 57% of the variance. In the appendix of this paper, the matrix of component loadings is shown. The first component reflects the practices of employee involvement, external involvement and external networking. The second component contains R&D outsourcing and outward and inward IP licensing. The third one relates to venturing and external participation. Since the PCA was done to reduce the number of dimensions, we did not attempt to label these components, but instead used the three factor scores as a basis for our cluster exercise.

In the cluster analysis we combined hierarchical and non-hierarchical techniques. This helps to obtain more stable and robust taxonomies (Milligan and Sokol, 1980; Punj and Stewart, 1983). The hierarchical analysis was done with Ward's method based on squared Euclidian distances. Next, non-hierarchical cluster analyses were done to determine a final solution. We considered a range of initial solutions from the hierarchical analysis with either

two, three, four or five groups (as suggested by the dendogram). For each number of groups (k), we performed a k-means non-hierarchical analysis, in which SMEs were iteratively divided to the groups based on their distance to the centroids of our initial hierarchical solutions for (following Milligan and Sokol, 1980; Punj and Stewart, 1983). To assess which solution was most stable we computed kappa, the chance corrected coefficient of agreement (Singh, 1990), between each initial and final solution. The three-cluster solution appeared to be optimal ($k = 0.95$, while $k < 0.94$ for the other solutions).

A basic validity requirement is that one should find significant differences between the variables used to develop the clusters (Hair et al., 1998). Kruskal–Wallis tests confirmed this for all variables (Table 6). Again, all significances reported here are robust, i.e. either parametric or non-parametric tests give identical results.

Firms in cluster 1 are most strongly involved in open innovation. They use a broad set of innovation practices to improve their innovation performance and are on average larger and are relatively more based in manufacturing industries compared to the other two clusters. Cluster 2 is the largest group of firms; these enterprises nearly always rely on the involvement of employees and customers, and external networking, features which are shared with cluster 1. Cluster 3 includes innovative firms that rely heavily on customer involvement but most of them are not involved in relatively complex and formalized transaction forms of open innovation activities such as venturing, IP-trading, outsourcing of R&D and participation in other firms. The clusters provide a similar view on how SMEs apply open innovation practices as was earlier identified by Lichtenthaler (2008) for medium-sized and large manufacturers. Most enterprises have adopted either open or closed strategies on both technology exploration and exploitation activities, i.e. only few respondents are found with decidedly high scores on one dimension and low scores on the other, and there are not sufficient of them to form separate clusters.

To further explore the differences between clusters, Table 7 compares average trend scores for the application of innovation practices in the past 7 years. Respondents in cluster 1, which are strongly embracing open innovation, also intensified the adoption of the open model the most. The opposite applies to the third cluster. In other words, the differences between the three clusters are growing over time. Nevertheless, there is a trend towards increased adoption of open innovation in all clusters; only inward IP licensing is becoming less popular in the third cluster.

Table 6
Incidence of open innovation practices across three clusters

	Cluster1 ($n = 133$) (%)	Cluster2 ($n = 411$) (%)	Cluster3 ($n = 61$) (%)	Kruskal-Wallis χ^2 (df = 2)
Technology exploitation				
Venturing	40	27	15	14.5*
Outward IP licensing	44	1	0	227.3**
Employee involvement	98	99	38	340.5**
Technology exploration				
Customer involvement	98	99	77	109.3**
External networking	99	100	44	310.2**
External participation	44	31	11	20.4**
Outsourcing R&D	70	48	21	41.5**
Inward IP licensing	86	0	5	486.9**

**$p < 0.001$, *$p < 0.01$, ^$p < 0.05$.

Table 7
Perceived trend[a] in open innovation practices across three clusters

	Cluster1 ($n = 133$)	Cluster2 ($n = 411$)	Cluster3 ($n = 61$)	Kruskal-Wallis χ^2 (df = 2)
Technology exploitation				
Venturing	0.17	0.11	0.05	5.2
Outward IP licensing	0.11	0.00	0.00	26.0**
Employee involvement	0.53	0.43	0.07	36.1**
Technology exploration				
Customer involvement	0.52	0.38	0.05	36.3**
External networking	0.29	0.27	0.05	11.5*
External participation	0.23	0.14	0.02	14.6*
Outsourcing R&D	0.21	0.18	0.07	4.9
Inward IP licensing	0.17	0.00	−0.03	47.4**

**$p < 0.001$, *$p < 0.01$, ^$p < 0.05$.
[a]Average score with increase coded 1, stable coded 0 and decrease coded −1.

We also investigated if enterprises in the three clusters are evenly distributed across industries and size classes (see Table 6). As for industries, 58% of the respondents in cluster 1 are manufacturing companies. In clusters 2 and 3 these percentages are 55 and 43, respectively. A Kruskal–Wallis test shows that these differences are significant at $p<0.05$ (Kruskal–Wallis $\chi^2 = 7.3$, $df = 2$). Focusing on size classes, 55% of the respondents in cluster 1 are medium-sized enterprises. In clusters 2 and 3 these shares are 34% and 25%, respectively. Again, the differences are significant, now at $p<0.001$ (Kruskal–Wallis $\chi^2 = 23.1$, $df = 2$). It thus appears that enterprises in cluster 1 (open innovators) tend to be larger organizations. These results suggest a sequence in the adoption of open innovation practices as organizations grow. Cluster 3 contains many small enterprises with modest application of open innovation, but even here a majority of firms involves customers in their innovation processes. The most distinctive feature of cluster 2 is that these SMEs all engage in practices which can be organized informally and which do not necessarily require substantial investments, including employee involvement and external networking. Medium-sized enterprises are clearly over-represented and their innovation activities are also marked by practices which usually demand substantial investments, including venturing, external participations, IP licensing and R&D outsourcing.

5.4. Motives and challenges

The results analyzed in the previous section show that SMEs clearly have taken up a more open approach towards innovation. An important part of the survey focused on the motives and challenges of SMEs when pursuing open innovation. Table 8 shows that for almost all open innovation practices pursued by SMEs, the most important motives are market-related ones. For the majority of respondents, using new innovation methods is regarded as a way to keep up with market developments and to meet customer demand, which eventually should result in increased growth, better financial results, or increased market share. Market-related motives are the most important determinant for companies to engage in venturing (31%), to participate in other firms (36%) and to involve user in the innovation process (61%). Many SMEs believe it is necessary to use a broad set of methods to meet the ever-changing customer demand and to prevent the firm from being outperformed by competitors or new entrants. Motives related to control, focus, costs and capacity are mentioned less frequently.

An important finding is that the different innovation practices seem to have the same underlying motives. This implies that venturing, participation in other firms, inter-organizational networks and customer involvement are

Table 8
Motives to adopt open innovation practices

Category	Examples	Technology exploitation			Technology exploration		
		Venturing ($n = 83$) (%)	Employee involvement ($n = 256$) (%)	Customer involvement ($n = 232$) (%)	External networking ($n = 175$) (%)	External participation ($n = 94$) (%)	Outsourcing R&D ($n = 134$) (%)
Control	Increased control over activities, better organization of complex processes	1	9	1	1	3	1
Focus	Fit with core competencies, clear focus of firm activities	8	–	–	1	1	3
Innovation process	Improved product development, process-/market innovation, integration of new technologies	23	–	19	21	24	8
Knowledge	Gain knowledge, bring expertise to the firm	4	–	5	35	6	44
Costs	Cost management, profitability, efficiency	13	–	2	2	11	9
Capacity	Cannot do it alone, counterbalance lack of capacity	1	–	3	7	5	13
Market	Keep up with current market developments, customers, increase growth and/or market share	3	13	61	22	36	14
Utilization	Optimal use of talents, knowledge, qualities, and initiatives of employees	–	30	–	–	–	–
Policy	Organization principles, management conviction that involvement of employees is desirable	–	15	–	–	–	–
Motivation	Involvement of employees in the innovation process increases their motivation and commitment	–	22	–	–	–	–
Other		19	11	9	11	14	8
Total		100	100	100	100	100	100

complementary innovation activities in improving product development, integrating new technologies and keeping up with current market developments.

Employee involvement is the only item where motives are different than for the other items. SMEs capitalize on the knowledge and initiatives of their (non-R&D) employees for optimal use of human capital and for market considerations. However, employee involvement is also the outcome of an 'internal organizational policy' or it is stimulated to improve motivation and commitment of employees. These two motives are not necessarily dictated by innovation objectives.

Table 9 identifies the main managerial and organizational challenges that SMEs perceive when they adopt open innovation practices. We remind that interviewers first asked if respondents had experienced any barriers to open innovation. If respondents answered positively, the interviewer explored the nature of these barriers by open-ended questions. The main barriers to innovation mentioned by the respondents are related to venturing (mentioned by 48% of the respondents), external participation (48%), and outsourcing of R&D (43%).

Table 9 shows the extent to which the barriers mentioned above matter for each of the different types of open innovation activities. Organization and corporate culture-related issues that typically emerge when two or more companies are working together are clearly the most important barriers/ that firms face when they engage in venturing (35%), participation in other firms (75%), and the involvement of external parties and users (resp. 48% and 30%). These types of open innovation require cooperation among different organizations, or, in the case of venturing, employees who leave the organization. These inter-organizational relationships frequently lead to problems concerning the division of tasks and responsibility, the balance between innovation and day-to-day management tasks, and communication problems within and between organizations.

The availability of time and resources is another barrier. This is a barrier for almost all types of open innovation practices but the relatively low scores in Table 9 indicate that time and resources are not the most important barriers to implement open innovation practices. Administration-related problems occur much more frequently, typically in the context of venturing (28%), participation in other firms (13%) and the involvement of external parties (10%), more specifically when cooperating with governmental or other not-for-profit institutions. Administrative burdens are also prominent when the company receives governmental subsidies and grants. Governmental support is experienced

Table 9
Hampering factors when adopting open innovation practices

Category	Examples	Technology exploitation			Technology exploration		
		Venturing ($n = 40$) (%)	Employee involvement ($n = 88$) (%)	Customer involvement ($n = 68$) (%)	External networking ($n = 53$) (%)	External participation ($n = 45$) (%)	Outsourcing R&D ($n = 57$) (%)
Administration	Bureaucracy, administrative burdens, conflicting rules	28	–	–	10	13	19
Finance	Obtaining financial resources	10	–	–	5	–	4
Knowledge	Lack of technological knowledge, competent personnel, or legal/administrative knowledge	5	–	–	–	5	–
Marketing	Insufficient market intelligence, market affinity, marketing problems of products	10	–	–	–	5	–
Organization/ culture	Balancing innovation and daily tasks, communication problems, aligning partners, organization of innovation	35	–	30	48	75	36
Resources	Costs of innovation, time needed	5	17	10	7	–	10
IPR	Ownership of developed innovations, user rights when different parties cooperate	–	–	10	5	–	–
Quality of partners	Partner does not meet expectations, deadlines are not met	–	–	–	24	–	28
Adoption	Adoption problems, customer requirements misjudged	–	–	14	–	–	–
Demand	Customer demand too specific, innovation appears not to fit the market	–	–	28	–	–	–
Competences	Employees lack knowledge/competences, not enough labor flexibility	–	24	–	–	–	–
Commitment	Lack of employee commitment, resistance to change	–	51	–	–	–	–
Idea management	Employees have too many ideas, no management support	–	8	–	–	–	–
Other		7	–	8	1	2	3
Total		100	100	100	100	100	100

as being highly inflexible, also because it is not allowed to change partners and such programs cannot be ended prematurely.

In addition, every single open innovation practice creates its own specific problems. For instance, when companies involve external parties in the innovation process, they frequently report that these partners cannot meet the expectations or deliver the required quality of a product or a service. User involvement goes together with problems related to property rights, adoption and too specific customer demands. When relying on employees to implement open innovation, it often turns out that they do not have the required capabilities or skills to make a valuable contribution to innovation, or they lack motivation to do so. It also happens that in the end, management decides not to take up any of the ideas provided by employees or that the number of ideas coming from individual employees just gets too large to handle in an efficient way. This, in turn, poses new challenges to managers when they want to get the most out of the creativity of large numbers of individuals. Eventually they can get assistance from a growing number of specialized services firms to execute this job.

Overall, we can conclude that many barriers for open innovation in SMEs are related to corporate organization and culture, no matter which type of open innovation is pursued. On top of that, different types of open innovation also have their own specific types of problems and barriers to overcome. Remark also that the number of observations in Table 9 is quite smaller than in Table 8. There are three possible explanations for this observation: first, it can indicate that many respondents did not experience any barriers to implement open innovation practices; next, respondents may not be aware of any barriers because they cannot compare them with best practices; finally, respondents were aware of some problems but could not articulate them.

6. Discussion

6.1. Conclusions

Open innovation research has so far focused on large and multinational enterprises (MNEs). Open innovation practices in innovating SMEs have been neglected. This study addresses this gap by exploring the incidence of and trends towards open innovation in SMEs. Drawing on a survey database of 605 innovative SMEs in the Netherlands, we conclude that SMEs are practicing extensively open innovation activities, and, more importantly, that they are increasingly doing so. In all, open innovation is relevant and present in business life, i.e. it applies not just to MNEs but also to a much broader group of small- and medium-sized enterprises. Our results are in line with the recent survey study of Lichtenthaler (2008) who demonstrated that medium-sized and large manufacturers embrace open innovation practices.

Drawing on an existing database, open innovation was operationalized along two dimensions, i.e. technology exploitation (reflecting innovation practices to organize purposive outflows of knowledge) and technology exploration (purposive inflows of knowledge). For technology exploitation, our data suggests that many SMEs attempt to benefit from the initiatives and knowledge of their (non-R&D) workers. For technology exploration, by far most SMEs somehow try to involve their customers in innovation processes by tracking their modifications in products, proactively involving them in market research, etc. This result confirms the importance of user innovation (Von Hippel, 2005) for many SMEs: reducing the focus of open innovation in SMEs to science-driven innovations would seriously bias our understanding of open innovation for this category of firms. Furthermore, external networking to acquire new or missing knowledge is an important open innovation activity among SMEs. In contrast, outward and inward IP licensing, venturing activities and external participations are only practiced by a minority of the respondents. The more popular practices like customer involvement and external networking are informal, unstructured practices which do not necessarily require substantial investments. IP licensing, venturing and external participation on the contrary, require financial investments, formalized contracts and a structured innovation portfolio approach to manage the risks. This finding is in line with former studies about innovation in SMEs (e.g. Vossen, 1998).

One of the major objectives of the survey was to know whether open innovation is increasingly practiced by SMEs during the last 7 years. Respondents unequivocally perceive a trend towards increased popularity and dissemination of open innovation. Our findings suggest that innovation in SMEs is becoming more open. This is not surprising, considering the increasingly important role small- and medium-sized firms play in innovation. After all, small firms often lack resources to develop and commercialize new products in-house and, as a result, are more often inclined or forced to collaborate with other organizations.

Drawing on previous work we expected that the incidence and trend towards open innovation would be stronger for manufacturing companies and medium-sized enterprises (as opposed to services companies and small enterprises, respectively). Manufacturing firms are on average more active in the outsourcing of R&D and the out-licensing of IP, a result that is not surprising given the technological commitment of these firms, but they do not differ from service firms on other open innovation activities. This is an important finding; open innovation is as relevant for service firms as it is for manufacturing firms, and research about open innovation should not be limited to those SMEs that have formal R&D activities. This result is in line with Lichtenthaler's findings (2008). He investigated differences between industries in more detail, and found no significant differences either.

In contrast, we found significant differences in the adaption of open innovation practices between different size classes. Medium-sized enterprises engage in and adopt open innovation more often than small enterprises. These firms dispose of the required scale and resources to organize a broader range of innovation activities, and compared to small enterprises they may be considered as larger repositories of knowledge that can be purposively outsourced. The survey results furthermore reveal that open innovation is present in and increasingly adopted by small enterprises as well, but the adaption rate for all exploration activities grows faster for medium-sized firms than for small firms. This result indicates a divergent evolution between medium-sized firms and their smaller counterparts.

Cluster analysis revealed three groups of SMEs, clustering firms into groups with similar open innovation practices. Their features confirm Lichtenthaler's (2008) conclusion that companies seldom focus on either technology exploitation or technology exploration. Rather, open innovating companies tend to combine these two aspects of open innovation. Besides, as the cluster of most 'open' innovators has relatively more medium-sized companies, the clustering implicitly suggests a sequence in the adoption of open innovation, starting with customer involvement, following with employee involvement and external networking, and ending with more 'advanced' practices like IP licensing, R&D outsourcing, venturing and external participations.

The paper also explored motives of SMEs to get engaged into open innovation and the barriers managers experience in implementing it in the organization. The results indicate that open innovation in SMEs is mainly motivated by market-related targets: SMEs make use of several open innovation practices at the same time to serve customers effectively or to open up new markets, with higher-order objectives to secure revenues and to maintain growth. This finding corresponds with Gans and Stern (2003), who argued that the main problem of small enterprises is not so much invention but commercialization. Cooperation with industry incumbents might be one way to overcome the difficulties of commercialization. Knowledge acquisition and the effectiveness of innovation processes are also frequently mentioned, usually in the context of technology exploration practices. Cost and control considerations were mentioned much less often.

The managerial and organizational barriers to open innovation are very diverse, but the main barrier to open innovation in SMEs is related to the organizational and cultural issues which arise when SMEs start to interact and collaborate with external partners. These issues are encountered in a range of innovation activities, including venturing, customer involvement, external networking, R&D outsourcing and external participations.

6.2. Limitations

The current study is a first exploration of the open innovation practices in SMEs. Consequently, it has several limitations. We identified four major limitations. First, the measurement of some open innovation practices was very general as some practices were broadly defined. This particularly applies to employee involvement, customer involvement and external networking. These innovation practices were introduced to respondents in such a way that most respondents affirmed they were applying these practices. Although it is uncertain how the definitions have influenced the outcomes, we probably would get a more precise view on open innovation in SMEs with more narrowly defined practices. External networking was for example defined as 'drawing on or collaborating with external network partners to support innovation processes, for example for external knowledge or human capital' (Table 2). This practice would include formal strategic alliances with multiple partners to enable ground-breaking research, but also relatively simple, informal contacts with suppliers to develop process innovations. Future attempts to survey open innovation in broad samples of enterprises should delineate the several practices in a more detailed and accurate way.

Next, the list of open innovation indicators is probably not a complete list. Past studies have proposed other practices that were not included in the survey. Examples include the globalization of innovation activities and the early involved of suppliers in innovation processes (see Gassmann, 2006). One may argue that globalization of the innovation process is not relevant for SMEs. Nevertheless, we suggest that globalization should be included to complete the picture. As a consequence, we cannot claim that our survey data capture the full domain of external technology exploitation and exploration.

Although our sample of SMEs is extensive, there is still a chance that some types of enterprises were still overlooked. The screening of respondents implied that start-ups and micro-enterprises (with less than ten employees) were excluded. As these enterprises have been repeatedly identified as sources of breakthrough innovations and challengers of incumbent innovation actors (e.g. Schumpeter, 1934), this is an issue that future researchers should pick up. Moreover, the screening of respondents based on the presence of innovation activities distorts the 'representativeness' of our sample, i.e. results cannot be generalized to the population of Dutch enterprises with 10–499 employees. This is partly due to the screening questions, but also because it was decided that manufacturers had to be over-sampled at the expense of services. Manufacturers are heavy-users of innovation policies, and for 'political' reasons the commissioner of the survey had requested detailed covering of this group. Nevertheless, the sample does reflect a broad group of innovative SMEs that goes beyond the scope of past open innovation studies.

Finally, motives and perceived challenges were surveyed only if respondents reported that they had adopted the corresponding practices. Due to limited numbers of respondents our conclusions are only tentative, and for

outward and inward IP licensing, no results could be reported. This is regrettable because IP licensing is an aspect of open innovation that is still in its nascent phase (Chesbrough et al., 2006) and probably in most need of detailed investigation (Lichtenthaler, 2007).

6.3. Suggestions for further research

Despite these limitations, the findings of the current study should encourage scholars to analyze in greater depth open innovation in SMEs. First and foremost, our results indicate that open innovation is relevant for much broader groups of enterprises than just large and multinational enterprises or high-tech manufacturing firms, i.e. the open model is present and increasingly applied in the whole economy. Future research should broaden the scope by studying open innovation in broader samples, also capturing small enterprises and firms in services industries.

Open innovation studies have so far been dominated by qualitative research approaches, drawing heavily on in-depth interviews and case studies. Such methods are welcome to charter relatively new phenomena and to develop theories (Eisenhardt, 1989), but we anticipate that in the further research on open innovation, quantitative research methods will and should be applied more often in order to generalize research outcomes and to test hypotheses. This is also relevant for policy makers who will find it hard to justify and develop policies for open innovation as long as there are no statistics demonstrating that open innovation is relevant for large business populations. We consider it a challenge for statistical offices to adapt current innovation surveys to better reflect open innovation. In this context, we remark that current innovation surveys such as the CIS mainly focus on R&D and innovation investments of enterprises, and external networking activities, but do not pay attention to other open innovation practices (OECD, 2005). Especially technology exploitation activities are overlooked. The survey presented here might inspire statistical offices to modify their surveys, although the above-mentioned limitations should certainly be accounted for.

The dynamics of open innovation in SMEs is another research area that should be further developed. Our findings suggest that some open innovation activities are easy to implement while others may be picked up later in the growth cycle of the firm. Cluster analysis revealed three homogeneous groups of SMEs with similar application of open innovation practices. The clusters implicitly suggest a sequence in the adoption of open innovation, starting with customer involvement, following with employee involvement and external networking, and ending with more advanced practices which require formal budgets and greater size, e.g. IP licensing, R&D outsourcing, venturing and external participations. Future work should further investigate how organizations engage in open innovation during these growth phases, and what managerial implications can be derived.

In addition, the current survey does not study how large and small firms interact in open innovation. Christensen et al. (2005) shows that large, established companies and small start-ups manage open innovation differently, reflecting their differential position within the innovation system. Hence, future research should focus on the requirements of open innovation on differences in culture, structure and decision making between partners of different sizes and from different industries.

A final recommendation is to study the motives and challenges related to open innovation in more detail. We found that market considerations were the most important reason for SMEs to engage in open innovation. This suggests that SMEs are motivated to capitalize on their internal knowledge and to find alternative pathways to markets. It seems that future research should pay more attention to the purposive outflows of knowledge, i.e. technology exploitation activities. This recommendation is consistent with Lichtenthaler's (2008) observation that the innovation processes of many enterprises are increasingly marked by external technology acquisition, but that external technology exploitation to commercialize technologies is of a more recent date (p. 148). As for the managerial challenges, we found that organizational and cultural issues are the key barriers to implement open innovation. This is well in line with past interview-based studies (e.g. Chesbrough and Crowther, 2006) and the current literature on inter-organizational collaboration in innovation. However the question remains how SMEs can best deal with this major barrier.

Annex. Principal component analysis

Table A1 shows component loadings of Open Innovation practices on three components with eigenvalues >1.0 (after varimax rotation). This solution explains 57% of the variance.

Table A1
Principal component analysis of open innovation practices ($n = 605$)

Open innovation practice	Component 1	Component 2	Component 3
Venturing	0.02	0.08	0.83
Outward IP licensing	−0.04	0.82	0.04
Employee involvement	0.72	0.13	0.01
Customer involvement	0.59	−0.08	0.10
External networking	0.81	0.07	0.01
External participation	0.11	0.07	0.81
Outsourcing R&D	0.21	0.51	0.13
Inward IP licensing	0.02	0.80	0.06
Variance explained (%)	25	17	15

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