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Abstract

Although evidence for open innovation practices has been provided for large MNEs, they have not yet been analyzed systematically for SMEs. This paper presents the results of a survey among 605 Dutch innovating SMEs. The results show that SMEs are increasingly adapting open innovation practices. Moreover, they indicate a difference in the adaption to open innovation between manufacturing and services firms, and between larger and smaller SMEs. Larger SMEs adapting more quickly and in a more structured and professionalized way to open innovation than smaller ones. The survey furthermore shows that SMEs generally pursue an open innovation strategy to realize market-related objectives such as meeting customer demands, or keeping up with competitors. In addition, the results show that the most important barriers respondents face are related to the organizational and cultural differences when cooperating with other partners. Other serious barriers are administrative burdens, financing and knowledge transfer problems.

Keywords

Open innovation, SMEs, motives for and barriers to cooperation

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1. INTRODUCTION

Companies consider innovations as a major engine to enhance their performance and to strengthen their competitive position in the market. Many firms have paid most of their management attention to a greater focus on internal efficiencies of the development process, team structures, decision making and cross functional interaction. However, as more and more companies bring innovation straight to the heart of their corporate strategies, developing internal innovation capabilities is no longer sufficient to gain and sustain competitive advantage. Since innovation strategies look increasingly similar and commoditized, more and more organizations try to further improve their innovation performance through intensifying collaboration across industry networks and partnerships, opening up their innovation processes in line with the open innovation framework (Chesbrough 2003, 2006; EIRMA, 2004).

Traditionally, open innovation has been analyzed mainly within the context of large, multinational, technology firms (Chesbrough, 2003). Although Chesbrough et al. (2006) argue that large firms could differ from small firms in their adoption of open innovation, only a small number of studies on open innovation within smaller firms exist. For instance, Henkel (2006) examines both small and large firms, but focuses only on companies that develop open source software. Lecocq & Demil (2006) study the U.S. tabletop role-playing game industry, which is a highly fragmented industry with SMEs as the main players. Furthermore, Christensen et al. (2005) illustrate the role of small companies over the life cycle of the technology. They also show that firm size does influence the innovation strategy and value

capturing ability of firms on new technology. Nevertheless, prior studies have not yet systematically analyzed the notion of open innovation in SMEs. Hence, it still remains to a large extend an unanswered question how small firms adopt to open innovation. This paper addresses this gap by focusing on the open innovation practices in SMEs. Based on an exploratory survey among SMEs in the Netherlands, we intend to formulate an answer on the following questions: Is open innovation different for small firms as compared to large ones? Do we find homogeneous results for all SMEs or can we make a distinction between different types of open innovation-strategies in different categories of SMEs, such as services and manufacturing firms? What are the most important drivers for SMEs to start open innovation practices? What are the major barriers? SMEs do not have internal R&D labs and cannot rely on entrenched technological competences. They have to make systematic use of the competences of suppliers, customers, complementors (Nalebuff and Brandenburger, 1996) and other actors in the value system. Moreover, many SMEs are active in medium- or low-tech industries and do not have formalized R&D-activities.

The paper intends to contribute to the literature in several ways. First, this study is the first one to investigate the use of open innovation practices in SMEs in a systematic way and to identify the motives that drive firms to get involved in open innovation and the barriers that they face when pursuing a more open approach towards innovation. Second, the results of our study are based on a survey that operationalizes open innovation practices into different, measurable dimensions. Third, most prior research on open innovation is based on US based firms (e.g. Chesbrough, 2003; Chesbrough and Crowther, 2006; Lecocq and Demil, 2006) and research about open innovation practices in Europe have been scarce. This paper

contributes to fill that void by analyzing open innovation behavior in small and medium sized companies in the Netherlands.

The remainder of the paper is structured as follows. The next section discusses the concept of open innovation and the different dimensions that can be used to describe open innovation practices in firms. Next, we develop some theoretical arguments about the differences in adoption of open innovation between manufacturing and service firms, and between different size categories of SMEs. Furthermore, we analyze the motives that drive SMEs to get engaged in open innovation and the barriers the experience when implementing it. Thereafter, we describe the survey and sample selection, followed by an analysis of trends in open innovation practices. Next, we explore what motivates firms to start open innovation practices and what type of barriers they experience when they implement open innovation. Finally, we draw some conclusions from the survey results and develop ideas for future research.

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 represent a considerable barrier to entry for potential entrants. 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 as 'closed innovation' (Chesbrough, 2003). For a long time, closed innovation has been a very successful way used by companies to sustain a competitive advantage in their different businesses. However, the innovation landscape has changed considerably: good ideas are widely distributed with no firm

having a monopoly, venture capital is abundant nowadays and the acceleration of the product life cycle has turned intellectual property (IP) into an increasingly perishable asset. As a result, a growing number of large MNEs have been moving from an internally focused innovation process to one that is more 'open'. In this new era of 'open innovation', firms use both internal and external pathways to exploit technologies and, concurrently, they scout different external sources of technology that can accelerate their innovation process (Chesbrough, 2003). In addition to internal R&D, established companies need to get access to external knowledge, such as startups, universities, suppliers, or even competitors to stay competitive in the long run.

Open innovation is thus a broad concept, which encompasses different dimensions. First of all, there is the inside-out movement, or *technology exploitation*, in which existing technological capabilities are leveraged outside the boundaries of the firm. Next, there is an outside-in movement, also referred to as *technology exploration*, in which external sources of innovation are used to enhance current technological developments. In a fully open setting, companies combine both technology exploitation and technology exploration in order to create maximum value from their technological capabilities or other competencies.

2.1 Technology exploitation

Firms can implement various strategies to commercialize technologies via external pathways, such as creating and spinning out *new ventures*, and the *licensing of intellectual property* to external parties (Chesbrough, 2003). Previous research on open innovation has discussed the spin off process of large firms (e.g. Chesbrough, 2003; Lord et al., 2002); several large high-tech companies spin off new ventures

because the business idea does not fit into the existing business model. The potential for these spin off companies is enormous; Chesbrough (2003) illustrates 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.

In addition, firms can also profit from their own, unused IP when other firms with different business models find profitable, external paths to the market for an idea (Chesbrough, 2006). However, the ability of firms to be successfully trade IP depends also on the appropriability conditions (West, 2003). If the appropriation regime is weak (Teece, 1986), outgoing knowledge spillovers allow competitors to imitate innovations and capture its value at the cost of the innovating firm. Thus, firms have to use different intellectual property rights strategies to prevent such situations.

2.2 Technology exploration

On the other hand, there are also numerous ways in which a firm can get access to external sources of knowledge. Customers, employees and other firms are the most common sources of new ideas, but the use of venture capital, outsourcing of R&D and the licensing of other firms' IP are also becoming more common nowadays.

First of all, firms may benefit from *user-initiated innovations* by decreasing the need to generate and evaluate ideas or concepts, by reducing R&D and commercialization costs and by accelerating involving customers into the product development and commercialization process (Gales and Mansour-Cole, 1995). Failure to consider users' constrains and requirements in the design of innovation, often leads to difficulties in commercialization (Cooper and Kleinschmidt, 1995; Lettl et al., 2006). Hence, for successful adoption, the entire innovation process requires "mutual adaptation" (Leonard-Barton, 1988), mutually beneficial collaboration between

producer and user (Foxall and Johnston, 1987), and successful conflict resolution (Newman and Noble, 1990). Firms can involve customer information using different tactics in their innovation process; market research can be done to find out if customers prefer possible future characteristics of products. However, conventional market research methods may not work well in the instance of many industrial goods and services (Herstatt & Von Hippel, 1992). More recently, firms stimulate users to co-develop products or technologies, such as in the open source software (Henkel, 2004; Hienerth, 2006). This practice is also becoming fashionable in other industries such as car design, electronic games, or sports equipment (e.g. Franke and Shah, 2003; Von Hippel, 2005). Henkel (2004) argues that firms (adopting open source strategies) may make their technology available to the public in order to elicit development collaboration, but without any contractual guarantees of obtaining it.

Not only customers but also firms' *employees* can contribute to a firm's overall innovative performance. Both in closed and open innovation paradigms, individual employees play a crucial but different role. Thus, a firm should foster a culture in which these knowledge workers are motivated to continuously search for new ideas. In addition, firms that embark on open innovation should stimulate inter-organizational networking between employees of different firms. Several case studies illustrate that informal ties of employees with employees of other organizations or institutions are crucial to understand how new products are created and commercialized (Chesbrough et al., 2006). Morgan (1993) observed in the early nineties already that the role of formal reporting structures and detailed work processes had a diminished role in favor of informal networks of employees. These networks were in many cases cross-boundary linking employees of (locally bounded)

networks of firms. The strength and dynamics of these connected groups of employees has a significant impact on firms' knowledge creating capability).[1]

Another important dimension of technology exploration is inter-organizational *networking*. For instance, R&D alliances between non-competing firms have become a popular vehicle for acquiring and leveraging technological capabilities (Gomes-Casseres, 1997). In addition, firms increasingly team up with competitors to share R&D costs and associated risks. Because of the fact that firms can get locked in innovation networks, it is important to search for optimal network configurations (Rowley et al., 2000), which could also imply that they have to innovate in collaboration with competitors. In addition, more and more SME firms are entering into research collaborations with universities (e.g. George et al., 2002). Without academic research outcomes many innovations could not have been realized or would have come much later (Fontana et al., 2006). Scientific results brought about increased sales and higher research productivity and patenting activity for firms (Cohen et al., 1998). Additionally, interaction with suppliers & customers can provide missing external inputs into the learning process which the firm itself cannot (easily) provide (Romijn and Albaladejo, 2002; Von Hippel, 2005). Users in the form of economic markets inform the design of technology and may even initiate the development by others of desired innovations (Gales and Mansour-Cole, 1995). Predictions of sources of innovation can be based on whether users or developers are most likely to receive the greatest economic benefit (von Hippel, 1988). Moreover, Romijn and Albaladejo (2002) illustrate that firms may also use financial institutions

[1] Academics and practitioners have analyzed the benefits of networked governance structures such as joint ventures, partnerships, strategic alliances and R&D consortia on the effective creation and integration of knowledge across organizations. However, there has been much less attention paid to how informal networks of employees in networked organizations may facilitate (or hamper) knowledge creating and integration.

(banks, venture capitalists) as drivers for the development of new or improved products and or services.

Inter-organizational networking might also take the specific form of *participation in new or existing companies*, for instance through minority holdings or corporate venture capital investments (Chesbrough, 2002; Dushnitsky and Lenox, 2005a; Ernst et al., 2005). Through these kinds of equity investments, firms gain a "window" on new technological developments (Keil, 2002). Moreover, the equity investment might serve as the creation of an option to further increase collaboration with the partner firm in case the technology provides to be valuable for the investing firm (Van de Vrande et al., 2006). Prior studies have already shown that corporate venture capital investments have a positive effect on the innovative performance of firms (Dushnitsky and Lenox, 2005b; Wadhwa & Kotha, 2006).

Next, firms can engage in outsourcing of R&D or in-licensing of IP. By *outsourcing* we mean that firms enter arms-length agreements with third parties concerning the development of a new technology. In a world of closed innovation, the technologically complex parts of innovation should be done in-house, while the simpler parts could be outsourced. In an open innovation paradigm, other organizational forms to maximize the value caption effect could be in place; for instance Prencipe (2000) finds that aircraft engine manufacturers are able to retain knowledge about components whose production is outsourced. One specific engine maker was able to develop capabilities outside of the production, more focused on the integration of new technologies. This is in line with the role of a "network Orchestrator" (Lorenzoni and Baden-Fuller, 1995).

Finally IP plays a crucial role in open innovation as a result of the in-and outflows of ideas, (Arora, 2002; Chesbrough, 2003, 2006; Lichtenthaler, 2007). In

closed innovation, firms controlled their IP so that competitors could not profit from ideas. In open innovation, firms manage IP in a different way: they need to access external IP to fuel their own business model and to speed up and nurture their own research engine. This can be done by *licensing-in* other firms' IP to serve as a valuable add-on to the current business model of firms.

To conclude, open innovation in firms can take many different forms. It can be argued that the extent to which innovation processes in SMEs reflect these different dimensions depends on their size and the type of firm under study. This will be discussed in the next section.

3. INNOVATION IN SMALL AND MEDIUM-SIZED FIRMS

As the traditional scale advantages of large, internal R&D labs in established companies erode, open innovation recognizes that smaller firms take a more prominent role in the contemporary innovation landscape. Chesbrough (2003) provides evidence that small firms (firms with less than 1000 employees) continually increased their share of total industrial R&D spending in the US during the last two decades. More specifically, small firms account for around 24% of all US industry spending in 2005 – compared to 4% in 1981. The larger firms with more than 25.000 employees were still responsible for 38% of total industry R&D spending in 2005 compared to 71% in 1981 (National Science Foundation, 2006). Hence, although large companies are still playing a prominent role in innovation, smaller firms are becoming increasingly important for industry R&D and thus for economic growth.

3.1 Type of industry

SMEs can be divided in different ways but an interesting segmentation is the division between services and manufacturing firms. Prior studies have acknowledged the fact that services and manufacturing firms are fundamentally different. According to Atuahene-Gima (1996) services differ from products in terms of intangibility, inseparability, heterogeneity, and perishability. Intangibility refers to the fact that services can be regarded as experiences which makes it more difficult to assess their value before purchase. Inseparability highlights the role of the customer in the simultaneous production and consumption of the service. Heterogeneity and perishability point towards the variability in the quality of services and the inability to store services when supply exceeds demand. Their study shows how factors affecting the innovation potential differ greatly between these two groups of firms. Hence, one can expect that different dimensions of open innovation also will vary between services and manufacturing firms.

Traditionally, the importance of closed innovation was primarily highlighted for industrial firms. These firms were able to benefit from closed innovation because the in-house development and commercialization of their products was the only way to ensure that they would benefit from the inventions as well. However, the increasing technological complexity to produce new products, the short product life cycles, the mobility of engineers and the rise of the venture capital industry have forced these firms to open up their innovation processes. With products being 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 the current business line. Moreover, in- en out-licensing of intellectual property is more an issue in firms where the use and development of intellectual property is at the heart of the innovation strategy, which is

the case in manufacturing firms. Although service firms, on the other hand, will be inclined to use networks and customer and employee involvement in the innovation process, we expect to find that in general manufacturing firms are more involved in open innovation than service firms. Moreover, we expect that the increase in open innovation practices is stronger in manufacturing firms than in service firms since open innovation has been documented for manufacturing companies. Part of current movement towards open innovation is related to a different approach of universities, research labs and companies vis-à-vis technology and IP. We expect that the increase in use of open innovation practices has been more prominent in manufacturing companies since new technological developments are on average more important for manufacturing firms compared to service firms.

3.2 Size classes

Aside from the fact that SMEs are services or manufacturing firms, they also differ significantly in size. SMEs are defined as firms with up to 500 employees. However, there is still great difference in the innovation strategies of small firms (up to 100 employees) and medium sized enterprises (100-499 employees). The innovation processes of larger firms are typically more structured and professionalized, and larger firms typically have more resources than small firms. This has important implications for the use of open innovation in these firms. Although the use of inter-organizational networks, the involvement of employees and that of customers in the innovation processes seems to be equally feasible for both small and large SMEs, the extent to which SME companies establish new ventures as a part of their open innovation strategy is likely to depend on firm size. Outsourcing of R&D and the spinning out of new ventures requires a structured and well organized innovation

process. Moreover, participation in other firms also calls for a certain amount of equity which can be used to make high-risk investments with uncertain return on investment. Larger firms typically have more financial resources to engage in these kinds of investments. The same holds for the in- and out-licensing of intellectual property rights; in-licensing of IP requires financial slack, whereas out-licensing of IP requires the structure and processes to formalize such agreements. Moreover, licensing technology is not possible without patent righting skills. As a result, we expect that open innovation in general is more commonly used by large SMEs and that for this size class, the increase in open innovation is stronger than for their smaller counterparts.

3.3 Motives and barriers

Finally, we are interested in the motives and barriers that are involved with choosing a more open approach towards innovation. A large-scale study by EIRMA (2003) shows that the main motives for R&D managers in large corporations to participate in venturing activities is embedded in market-related arguments such as meeting customer demand, but also in collecting new ideas and knowledge, improving innovative performance, continuous growth and financial motives. In addition, Jacobs and Waalkens (2001) found that the main determinants to change the role of innovation within companies can be found in the improved capabilities for corporate renewal, shortening time-to-market, and better utilization of internal creativity. Hence, we expect the motives for firms to undertake open innovation activities to be related to market considerations and the creation of knowledge.

As far as potential barriers to open innovation are concerned, prior studies about cooperation between firms have frequently mentioned that organizational

structure and culture are very important problems related to innovation and knowledge transfer. According to Meschi (1997), most of the organizational difficulties in international joint ventures are rooted in cultural distance, be it national or organizational. Moreover, Simonin (1999) finds that both cultural and organizational distances are related to ambiguity, which in turn negatively affects knowledge transfer. A study developed by a selected group of European R&D managers EIRMA (2003) furthermore shows that the management of different organizational cultures is a key factor in inter-firm cooperation. Companies that follow a more open approach to innovation will need to organize the way in which they manage inter-organizational relationships and network management. For many companies, this is a challenging managing task: 'It has become essential to master the network' (EIRMA, 2004: iv). As a result, it is likely that barriers to open innovation are rooted in similar causes, including cultural and organizational problems as the most important items.

4. DATA AND METHODS

4.1 Survey description

To analyze trends, motives and management challenges related to open innovation, we used a dataset that was collected in 2005 by EIM, a research institute for business and policy research in the Netherlands. Because the survey's target was to explore open innovation trends in SMEs, it started with a number of screening questions. First, firms had to be labeled as ‘active innovators’, i.e. firms which have implemented at least one innovation during the period 2003-2005 and who claim that continuous renewal is part of their corporate strategy. In addition, the responding SMEs had to be established at least seven years ago and respondents had to work at

least 7 years at the firm to ensure that they were able to give an accurate judgment concerning the development of open innovation in their companies.

The sample was disproportionally stratified across both manufacturing and service industries and across the two size classes. Potential respondents were randomly drawn from the population of all small and medium-sized firms in the Netherlands, defined as all firms with no more than 500 employees. Firms with less than 10 employees (i.e. micro-firms) were excluded from the sample, because in general they have no or very limited in-house R&D activities. Besides, the population of micro-firms contains a relatively high share of start-ups. Such firms would not satisfy the criterion of SMEs that have to be in operation for at least seven years.

The population of firms was derived from a database of the Chambers of Commerce, containing data on all Dutch firms. The data were collected in December 2005, over a period of three weeks, by means of computer assisted telephone interviewing (CATI). All respondents were small business owners or managers and innovation decision-makers. Attempts to contact reference persons were made five times before considering persons as non-respondents. In total 2,230 respondents were contacted, of which 1,206 (54%) were willing to participate in our survey. To check for non-response bias, the distribution of respondents and non-respondents across type of industry and size class were compared. The chi-square-tests contrasting these groups revealed no significant differences at the 5% level ($p = 0.23$ for type of industry and $p = 0.55$ for size classes), indicating that non-response bias was not a serious problem.

After our screening questions 605 respondents satisfied both criteria (active innovator and long tenure), which corresponds with a final sampling rate of 27%.

Table 1 shows how respondents are distributed according to their type of industry and size class.

Table 1. Distribution of respondents across type of industry and size class

	Size class		
Type of industry	*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; 35-36)	47	53	
	160	128	**288**
Services:			
– IT (NACE code 72)	53	17	
– business services (NACE code 74)	59	24	
– other services (NACE codes 50-71; 92-93)	104	60	
	216	101	**317**
Total	**376**	**229**	**605**

4.2 Operationalizing open innovation

Open innovation was operationalized according to the different dimensions mentioned earlier in this paper[2].

4.2.1 Technology exploitation

To measure the extent to which firms were involved in technology exploitation, we use variables measuring if firms had ever spun out new ventures, or licensed-out their own intellectual property in the period 2003-2005.

In addition, respondents were asked to judge whether the use of these innovation strategies had increased, remained unchanged, or whether it had decreased in the period 2003-2005. Next, in case respondents had increased their usage of

[2] An overview of the questions is available from the authors upon request.

innovation strategies, they were invited to elaborate on their motives and perceived challenges in doing so.

4.2.2 Technology exploration

In similar vein, we included a number of questions on the use of technology exploration strategies. To address the role of customers, respondents were asked to which degree customers were involved in the innovation process, for instance by doing active market research, deploying new products which were specified by customers themselves, or producing new products based upon inventions by customers of users. The survey data contained a summary variable indicating customer involvement, i.e. a dummy coded 1 if firms used input from their customers in recent innovation processes.

To measure the role of employees, respondents had to indicate to which degree employees were stimulated to contribute to innovation processes, e.g. by investing in employees' ideas and initiatives, creating autonomous teams with own budgets to carry out innovations, or stimulating employees' external work contacts in order to enhance opportunity exploration. The survey data allowed distinguishing between employees that belong to the R&D department and those that are coming from other organizational parts of the company.

Furthermore, the survey also investigated whether firms collaborated with the different types of partners as described above, including complementors, competitors, public knowledge centers (e.g. universities), customers, suppliers, and investors (e.g. banks, venture capital firms).

Finally, we looked at the degree firms participate by equity investments in new or existing companies, we asked whether respondents had ever outsourced R&D in the period 2003-2005, and to what extent the firm licensed IP from other firms.

For each type of technology exploration, respondents were asked to indicate whether the use of this particular type had increased, decreased or whether it remained unchanged in the period 2003-2005. In addition, respondents were again given the opportunity to elaborate on their motives and perceived challenges for each of these technology exploration mechanisms by means of open-ended questions.

5. RESULTS

A summary of the key open innovation practices in the Dutch SMEs is presented in Table 2. The table shows the number of respondents that are actively involved in several open innovation practices and the perceptual change of these practices in the period 2003-2005.

Table 2. Open innovation practices and their perceived change over time (n=605)

open innovation indicator	*Use*	*Perceived change*		
		increase	*no change*	*decrease*
Technology exploitation				
Venturing	29%	14%	85%	2%
License IP to other firms	10%	3%	95%	1%
Technology exploitation				
Customer involvement	97%	38%	61%	1%
Employee involvement	93%	42%	57%	1%
Network usage in innovation processes	94%	29%	67%	4%
Participation in other firms	32%	16%	84%	1%
Outsourcing R&D	50%	22%	73%	5%
License IP from other firms	20%	5%	93%	2%

Table 2 clearly shows that network usage in innovation processes and the involvement of network partners, customers and employees in innovation processes is fairly

common among Dutch SMEs. Licensing IP, venturing and participation in other firms are open innovation practices that are explored only by a minority if the respondents.

The most striking result is that the share of respondents who perceive an intensification of the use of these open innovation practices is substantially larger than those who experience a decrease. This is the case for all indicators in Table 2. Especially employee involvement, customer involvement, the use of network partners and (to a lesser extent) outsourcing of R&D have experienced a substantial increase in popularity in the last three years.

5.1 Type of industry

Table 3 shows the share of manufacturing and service SMEs using open innovation practices. Customer involvement, employee involvement, and the usage of networks in the innovation process appear to be the main types of open innovation practices used by both manufacturing and services firms. Oneway analysis of variance furthermore demonstrates that outsourcing R&D is more frequently done by manufacturers. The same applies to licensing IP from other firms. In contrast, the results show that venturing is more popular among services firms compared to manufacturing firms service SMEs spin out new ventures more often. Thus, although manufacturing firms are involved to a larger extent in outsourcing of R&D and the licensing of IP from third parties, the results also show no difference between manufacturing firms and services firms for the other types of open innovation.

Table 3. Open innovation practices and perceived change in manufacturing and service SMEs

Open innovation indicator	*Use*			*Perceived change (1)*		
	Manufacturing (n=288)	*Services (n=317)*	*F-value*	*Manufacturing (n=288)*	*Services (n=317)*	*F-value*
Technology exploitation						
Venturing	24%	33%	5,8^	0.09	0.15	3,8^
License IP to other firms	11%	8%	1,5	0.02	0.02	0,1
Technology exploration						
Customer involvement	98%	97%	0,7	0.34	0.40	2,2
Employee involvement	94%	93%	0,4	0.41	0.41	0,1
Network usage in innovation processes	95%	94%	0,3	0.24	0.26	0,3
Participation in other firms	29%	34%	1,5	0.14	0.15	0,1
Outsourcing R&D	59%	43%	16,7**	0.23	0.13	5,9^
License IP from other firms	25%	15%	10,7*	0.04	0.03	0,4

(1) Mean score with increase coded 1, no change coded 0 and decrease coded -1

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

Table 3 also not only shows whether manufacturers and service firms deploy open innovation practices in a different way but also whether they perceive changes in popularity of these practices in a different way. Respondents from both manufacturing and service companies indicate that on average open innovation practices have been increasingly used in the last three years (as mean scores are positive for both types of firms). Oneway analysis of variance furthermore shows that manufacturers have experienced a stronger shift towards more outsourcing of R&D, while services firms experienced a stronger increase in new venturing. There are no statistical differences between the services and manufacturing SMEs for the other items.

5.2 Size classes

SMEs are not a homogenous group of firms. SMEs of different firm sizes are expected to deploy open innovation practices in different ways. As SMEs grow and reach a critical size, they organize the company in a more formal way, they hire specialists for a broad range of particular job functions and they formalize the firm's

strategy in order to ensure market positions against large(r) and international competitors. In many SMEs that reach a critical size, formal R&D and innovation practices start to play a critical role in developing and sustaining competitive advantages. At that point, firms are also thinking in a more deliberate way than smaller SMEs how to improve these innovating activities. Hence, since larger SMEs have more (formalized) internal R&D and innovation practices, we expect that the range of possibilities that open innovation practices offers is larger for large SMEs than for small ones. For the same reasons, we also expect that open innovation practices have been more rapidly embraced by larger SME as they have more to win from it.

Table 4 shows that larger SMEs (100-499 employees) are on average much stronger involved in outsourcing R&D, participation in other firms and in- and out-licensing, as compared to the small SMEs (< 100 employees). Both size categories show no significant differences with respect to customer and employee involvement, networking with partners because these are practices that have no discriminating power since all firms are actively involved in them. Only a minority of small and large SMEs is involved in venturing but there is no clear relation with firm size.

Table 4. Open innovation practices and perceived change across size classes

Open innovation indicator	*Use*			*Perceived change (1)*		
	10-99 employees (n=376)	*100-499 employees (n=229)*	*F-value*	*10-99 employees (n=376)*	*100-499 employees (n=229)*	*F-value*
Technology exploitation						
Venturing	27%	32%	1,9	0.11	0.14	1,5
License IP to other firms	6%	16%	18,9**	0.01	0.04	2,1
Technology exploration						
Customer involvement	97%	98%	1,2	0.30	0.50	22,8**
Employee involvement	92%	96%	3,0	0.37	0.48	7,5*
Network usage in innovation processes	94%	95%	0,2	0.20	0.33	8,8*
Participation in other firms	24%	44%	28,0**	0.13	0.18	3,9^
Outsourcing R&D	42%	64%	27,3**	0.14	0.24	5,7^
License IP from other firms	14%	29%	23,1**	0.02	0.07	4,8^

(1) Mean score with increase coded 1, no change coded 0 and decrease coded -1

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

There is a substantial difference between small and large SMEs in their adaptation rate of open innovation practices. All values in the two columns are higher for the larger SMEs indicating that they adopted open innovation practices more quickly than smaller firms. These differences in adoption rate are all significant with the exception of venturing and licensing IP to other companies, showing that overall, larger SMEs experience a stronger increase in the use of open innovation practices compared to smaller SMEs. The results indicate that there might be a growing differentiation between small and larger SMEs in adapting open innovation because larger SMEs are relatively more involved in open innovation and they experience stronger growth in adapting open innovation practices than their smaller counterparts

5.3 Clusters

To explore patterns of open innovation among SMEs we relied on cluster analysis techniques. These are sensitive to the selection of the variables used, since the addition of irrelevant variables can have a serious effect on the results of the

clustering (Milligan and Cooper, 1987). Cluster variables should also be representative for the typology one wants to present (Everitt, 1993). Here, we selected Table 2's indicators to explore whether the SME population contained any homogeneous groups of firms with similar use of open innovation practices.

Our analysis consists of three steps. We started with a principal component analysis to reduce the number of dimensions in our indicators. Next, we applied cluster analysis techniques to explore patterns of open innovation practices among SMEs. Finally, we used oneway analysis of variance to validate the taxonomy.

Several studies that perform taxonomies of innovation patterns use Principal Component Analysis (PCA), as a way to reduce the number of dimensions to be used in the clustering. In general, PCA reduces the risk that single indicators dominate a cluster solution, and helps to prevent the inclusion of irrelevant (non-discriminative) variables (Everitt, 1993; Hair et al., 1998). Another advantage is that the factors obtained from a PCA are uncorrelated and therefore no variable would implicitly be weighted more heavily in the clustering and thus dominate the cluster solution (Hair et al., 1998, p. 491). We first tested if our data were suitable for a component analysis, by calculating Measures of Sampling Adequacy (MSA) for the individual variables (Hair et al., 1998). All the variables had satisfactory values (> 0.57) and were suitable candidates for a PCA. In addition, KMO and Bartlett's test of sphericity met common standards ($KMO = 0.61$ and $p(Bartlett) < 0.001$) (Hair et al., 1998). In performing the principal component analysis, we used the extraction technique with varimax rotation and, for the selection of the number of factors, we applied the latent root criterion, requiring that the eigenvalues are greater than one. As result, we obtained a three-

dimensional solution explaining 57% of the variance. Since we used the PCA in order to reduce the number of dimensions the output is not presented here[3].

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). We first carried out a hierarchical analysis to group SMEs into homogeneous clusters, by using the Ward's method based on squared Euclidian distances. Homogeneous groups are built so as to minimize the distance in scores of firms within a single cluster and to maximize the distance in scores between companies from the various clusters. Next, non-hierarchical cluster analyses were carried out to improve the initial solutions and to select the number of clusters for the taxonomy. At first, a visual inspection of the dendogram, plotting the initial solutions of the hierarchical analysis, suggested that a taxonomy with either three of four clusters could be feasible. For a better assessment of robustness we considered a range of initial solutions from the hierarchical analysis, going from two up to five clusters. For each number of clusters (k), we perform a k-means 'non-hierarchical' cluster analysis, in which SMEs were iteratively divided into clusters based on their distance to some initial starting points of dimension k. While some k-means methods use randomly selected starting points, we employed the centroids of our initial hierarchical solutions for this purpose (cf. Milligan and Sokol, 1980; Punj and Stewart, 1983). To assess which solution should be preferred we computed Kappa, the chance corrected coefficient of agreement (Singh, 1990), between each initial and final solution. The three-cluster solution appeared to have the highest value of Kappa ($k = 0.95$, while $k < 0.94$ for the other solutions).

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[3] The results can be obtained from the authors.

As a basic validity requirement we checked for significant differences on the variables used to develop our taxonomy (Milligan and Cooper, 1987). One-way analyses of variance for each variable confirmed this (see Table 5).

Table 5. Open innovation practices across three clusters

	cluster1 (n=133)	*cluster2 (n=411)*	*cluster3 (n=61)*	*F-value*
Technology exploitation				
Venturing	40%	27%	15%	7,4**
License IP to other firms	44%	1%	0%	181,6**
Technology exploration				
Customer involvement	98%	99%	77%	66,5**
Employee involvement	98%	99%	38%	388,9**
Network usage in innovation processes	99%	100%	44%	317,7**
Participation in other firms	44%	31%	11%	10,5**
Outsourcing R&D	70%	48%	21%	22,2**
License IP from other firms	86%	0%	5%	351,5**

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

Firms in cluster 1 are strongly involved in all types of open innovation practices. They use a broad set of these practices to improve their innovation performance and are on average larger and more based in manufacturing compared to the other two clusters (see Table 6). Cluster 2 is the largest group. The firms in this cluster rely mainly on the involvement of network partners, customers and employees in their innovation processes. Some of them also rely on outsourcing of R&D, venturing and/or participation in other firms. Almost none of them trade in intellectual property. Cluster 3 includes innovative firms that only rely on customer involvement and networking with partners. 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.

To further explore the distinction between the three clusters, Table 6 reveals how respondents think about the changes that took place in the period 2003-2005. We added the information about firm size and share of manufacturing firms per cluster.

Cluster1 are the most important adopters of open innovation practices. Differences with the other clusters are significant on basically all open innovation indicators. They are involved in more complex and formalized open innovation activities. Their involvement in IP-sharing indicates that these firms also have a more technology based open innovation network. Firms in cluster 3 are poor adopters of open innovation practices. This is a relatively small group of companies that mainly rely on customer involvement and to a minor extent on employee involvement and network partners. This is, of course, a (too) narrow interpretation of open innovation.

Table 6. Perceived change (1) of open innovation practices, type of industry and size distributions across three open innovation clusters

	cluster1 (n=133)	*cluster2 (n=411)*	*cluster3 (n=61)*	*F-value*
Perceived change:				
Technology exploitation				
Venturing	0.17	0.11	0.05	3,5^
License IP to other firms	0.11	0.00	0.00	13,0**
Technology exploration				
Customer involvement	0.52	0.38	0.05	19,5**
Employee involvement	0.53	0.43	0.07	18,2**
Network usage in innovation processes	0.29	0.27	0.05	5,1*
Participation in other firms	0.23	0.14	0.02	7,4**
Outsourcing R&D	0.21	0.18	0.07	1,9
License IP from other firms	0.17	0.00	-0.03	24,4**
Sector and size distributions:				
Share of manufacturing firms (versus service firms)	58%	45%	43%	3,7^
Share of firms with 100-499 employees (vs. 10-99 empl.)	55%	34%	25%	12,0**

(1) Mean score with increase coded 1, no change coded 0 and decrease coded -1

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

How are open innovation practices evolving over time within the three SME-clusters? Table 6 indicates that the three clusters evolved in the direction of an intensified use of open innovation practices (there is only a small decrease in in-licensing in clusters 3). However, there are huge differences in the adaptation rate of the three clusters. Firms in cluster 1, which are strongly embracing open innovating, also intensified the

use of open innovation practices the most in the last three years. The opposite is true for the poor open innovation adopters in cluster 3. In other words, the differences between the three clusters are growing over time. The sector and size distributions are in line with our expectations. Cluster 1, consisting of firms which strongly embrace open innovation, includes the largest share of large SMEs (55%) and manufacturing firms (58%).

5.4 Motives for open innovation in SMEs

SMEs clearly have taken up a more open approach towards innovation. An important question in this respect is: what drives SMEs to open up the innovation process? Open questions in the inquiry allowed respondents to reveal their motives why their company is moving in the direction of an open innovation model. More specifically, companies were asked to clarify their motives when they get involved in the following 'open innovation'-practices: outsourcing of R&D, setting up new ventures, participation in new or existing firms, involvement of external partners in the innovation process, involvement of users in the innovation process, involvement of non-R&D employees in the innovation process.

The different 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. The coding process was organized with two reviewers. 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 2), the data did not contain enough records to provide reliable insights about respondents' motives and challenges on this topic.

Table 7. Classification of open innovation motives

Category	*Description*
Control	Increased control over activities, better organization of complex processes
Focus	Fit with core competencies, clear focus of firm activities
Renewal	Improved product development, process-/ market- innovation, integration of new technologies
Knowledge	Gain knowledge, bring expertise to the firm
Costs	Cost management, profitability, efficiency
Capacity	Cannot do it alone, counterbalance lack of capacity
Market	Keep up with current market developments, customers, increase growth and/or market share
Utilization*	Optimal use of talents, qualities, and ideas of current employees
Policy*	Organization principles, management conviction that involvement of employees is desirable
Motivation*	Involvement of employees in the innovation process increases their motivation and commitment

* Only used for coding motives related to employee-involvement

Table 8 below 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 should eventually result in increased growth, better results, or a bigger 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.

Another important reason for companies to engage in open innovation is the pursuit of corporate renewal. Corporate renewal refers to motives related to process innovation, the desire to develop products faster and more effective, or to incorporate new technologies in current products. One out of five respondents engaged in venturing, participation in other firms, involvement of external parties, and user

involvement lists corporate renewal as a reason to further pursue a specific innovation practice.

An important finding is that the different innovation practices have the same underlying motives. This implies that venturing, participation in other firms, inter-organizational networks and customer involvement are complementary innovation activities in improving product development, integrating new technologies and keeping up with current market developments. The only exception is improving the involvement of non-R&D employees in the innovation process: this innovation practice is related to three motives that are clearly different from the other motives.

Table 8. Motives for different types of open innovation

Motive		*Type of open innovation*					
		Outsourcing R&D (n=134)	Venturing (n=83)	Participation in other firms (n=94)	Network usage (n=175)	Customer involvement (n=232)	Employee involvement (n=256)
Control	%	1	1	3	1	1	9
Focus	%	3	8	0	1	0	-
Renewal	%	8	23	24	21	19	-
Knowledge	%	44	4	6	35	5	-
Costs	%	9	13	11	2	2	-
Capacity	%	13	0	5	7	3	-
Market	%	14	31	36	22	61	13
Utilization	%	-	-	-	-	-	30
Policy	%	-	-	-	-	-	15
Motivation	%	-	-	-	-	-	22
Other	%	8	19	14	11	10	11
Total	%	100	100	100	100	100	100

Employee involvement is the only type of innovation in which the respondents do not mention the objectives listed in the other types of innovation. Almost 30% of the respondents that involve non-R&D employees in their innovation process do so because they feel that the skills of their employees can be utilized in a more efficient way, and that they can complement the innovation initiatives of the management and/or R&D department. In addition, many companies involve employees for motivational reasons. Up to 15% of the respondents is convinced of the added value

of employee involvement for innovation; often this is part of the firm's policy in this case. Another 22% sees the involvement of employees mainly as a way to motivate them. The direct impact on the bottom-line in that case is less important as employees are primarily engaged in the innovation process to increase their overall performance on the job. Finally, market considerations are also important: after all, employees may be closely related to the market and therefore have a better idea than managers or engineers about the potential success of products and the problems they experience with customers. In this case, employee involvement is a valuable source of knowledge in the innovation process.

Finally, there are also motives that are primarily related to specific types of open innovation. For instance, 8% of the respondents list the corporate brand reputation as a reason to engage in venturing activities. In this case, the new venture commercializes products that do not fit the corporate brand or strategy. In addition, lack of internal knowledge forces SMEs to source new, externally developed knowledge and expertise (44%) and to get external actors involved in the firm's innovation process (35%). Another vital reason for the outsourcing of R&D is to gain from complementary resources in order to spread the risks and to compensate for a lack of current R&D capacity (13%).

5.5 Barriers to open innovation in SMEs

The barriers companies perceive when they pursue an open innovation strategy is another important issue in determining the success of open innovation in SMEs. For each of the different types of open innovation activities, respondents were asked to list the hurdles they experienced. The answers were again categorized using an open coding process. Table 9 shows the resulting classification.

Table 9. Classification of open innovation barriers

Category	*Description*
Administration	Bureaucracy, administrative burdens, conflicting rules
Finance	Obtaining financial resources
Knowledge	Lack of technological knowledge, lack of competent personnel, lack of legal/administrative knowledge
Marketing	Insufficient market intelligence, market affinity, marketing problems with new products
Organization/culture	Balancing innovation and daily tasks, communication problems, aligning partners, organization of innovation
Resources	Costs of innovation, time needed
Property rights	Ownership of developed innovations, user rights when different parties cooperate
Quality of partners	Partner does not meet expectations, deadlines are not met
User acceptance	Adoption problems, customer requirements misjudged
Customer demand	Customer demand too specific, innovation appears not to fit the market
Competent employees	Employees lack knowledge/competences, not enough labor flexibility
Commitment	Lack of employee commitment, resistance to change
Idea management	Employees have too many ideas, no management support

Table 10 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 barrier 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.

Table 10. Barriers to different types of open innovation

Motive		*Type of open innovation*				
		Venturing (n=40)	Participation in other firms (n=45)	Network usage (n=53)	Customer involvement (n=68)	Employee involvement (n=88)
Administration	%	28	13	10	-	-
Finance	%	10	0	5	-	-
Knowledge	%	5	5	-	-	-
Marketing	%	10	5	-	-	-
Organization/culture	%	35	75	48	30	-
Resources	%	5	0	7	10	17
Property rights	%	-	-	5	10	-
Quality of partners	%	-	-	24	-	-
User acceptance	%	-	-	-	13	-
Customer demand	%	-	-	-	28	-
Competent employees	%	-	-	-	-	24
Commitment	%	-	-	-	-	51
Idea management	%	-	-	-	-	8
Other	%	8	3	-	8	-
Total	%	100	100	100	100	100

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 10 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 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 has 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 involving employees, 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 the creativity of large numbers of individuals. Eventually they can get assistance from a growing number of specialized services firms to execute this job[4].

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 10 is quite smaller than in Table 9. 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 AND CONCLUSION

SMEs play an increasingly important role in innovation and job creation, but are nevertheless left out of the research on open innovation, which has been analyzed mainly within the context of large, technology user firms (Chesbrough, 2003). In this study we have addressed this gap by analyzing open innovation practices of SMEs in the Netherlands. The survey results indicate that open innovation is also becoming

4 A nice example is BIG Idea Group. See for more information Christensen and Anthony (2001).

increasingly popular among SMEs. This is not a 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 product in-house and as a result are more often inclined to collaborate with large,firms.

In addition, the survey results show that open innovation is not entirely different for services and manufacturing firms as we expected based on the literature. 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 with 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 SMEs that are involved in formal R&D activities. In contrast, we found significant differences between different SME-sizes. The results of the cluster analysis furthermore show that there are different open innovation strategies and practices among SMEs. We identified three clusters of firms that adapt open innovation practices in different ways. Consequently, further research about open innovation in SMEs should concentrate on these different strategies of SMEs to co-innovate with partners,

Finally, we identified several motives for firms to start open innovation practices and barriers that SME managers encounter when they open up their innovation process. Open innovation is mainly motivated by market-related targets: these are the most important driver for firms to engage in venturing, to participate in other firms and to involve user in the innovation process. Most SMEs use a broad set of methods to meet the ever-changing customer demand and to stay competitive. Corporate renewal is second most important driver towards open innovation. In

addition, many barriers for open innovation in SMEs are related to corporate organization and culture, no matter which type of open innovation practice is pursued.

Since the aim of this study was to explore the open innovation practices in small and medium sized enterprises, there are a number of avenues for future research. First, following up on the different clusters that were indentified in this study, future research needs to specify these different SME strategies how to tap into external innovation sources. Another conclusion we can draw from this clear segmentation of innovating SMEs is that research should not only focus on differences in open innovation practices between large firms and SMEs but also between different types of SMEs. There is certainly no one unique way in which SMEs deploy open innovation strategies, but we have no further specifications about these different strategies. 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. Next, our research does not indicate how SMEs get organized to manage open innovation-practices. Considering that the typical management challenges for SME-managers are quite different than those of managers of large firms that want to ignite the organic growth engine in their company, this is an interesting uncharted area for future research (Chesbrough et al., 2006). Finally, we did not explore how open innovation in SMEs is enhanced by the local or national innovation systems. The proximity of universities, research labs, large companies and lead users may play a role in the deployment of open innovation in SMEs. In similar

vein, an innovation policy fostering transactions between these innovation partners may also play a significant role.

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