DOCTORAL THESIS

Open Innovation in SMEs

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I hope that presenting this thesis is just the beginning of many good things to come.

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Chapter 1

Introduction

Open innovation, a term coined by Henry Chesbrough, can be defined as "a distributed innovation process based on purposively managed knowledge flows across organizational boundaries" (Chesbrough & Bogers, 2014: 17). Previously, large firms dominated markets by investing heavily in R&D, effectively raising the barriers of entry for smaller and younger firms. Open innovation is one of the reasons why, over the last decade, smaller and newer firms have begun to compete against large firms. These new firms are able to enter the market in a different way, despite the fact that in some cases they conduct no research of their own (Chesbrough, 2003). Current literature on open innovation has largely focused on large, multinational firms, and has overlooked the use of open innovation in small and medium-sized enterprises (Albors-Garrigós, Zabaleta Etxebarria, Hervas-Oliver, & Ganzarain Epelde, 2011; Lee, Park, Yoon, & Park, 2010). Due to the important role played by SMEs in the economy, a research gap has emerged in open innovation in SMEs. While research into open innovation in general is accelerating, research into open innovation in SMEs is still in its infancy, and presents a fascinating topic with wide-ranging, practical applications. Present studies have shown that the role of SMEs in open innovation is obvious and will grow in importance (Lee et al., 2010), and that the trend towards open innovation in SMEs is positive (van de Vrande, de Jong, Vanhaverbeke, & de Rochemont, 2009; Xiaobao, Wei, & Yuzhen, 2013).

Despite most well-known companies being large multinational firms, small and medium-sized enterprises (SMEs) in fact represent 99% of all businesses in the European Union, Japan and the United States, and account for more than half of employment in the non-financial business sector, with 52% in the United States, 66% in the EU, and 86% in Japan. SMEs thus contribute overwhelmingly to the economy, by underpinning employment and generating wealth. SMEs have fared better during the financial downturn than their larger counterparts, and have mitigated the negative effects on the economy (European Commission, 2014). Taking into consideration this

information, SMEs play a pivotal role in the economy, and are important drivers of innovation and economic growth (Eppinger & Vladova, 2013). Recent legislation in the EU also recognizes the important role SMEs play in the EU economy, such as the 2008 Small Business Act, which aims to reduce legislation and red tape which may be detrimental to SMEs, and more recently, to implement measures to stimulate growth (European Commission, 2014).

The Open Innovation Model

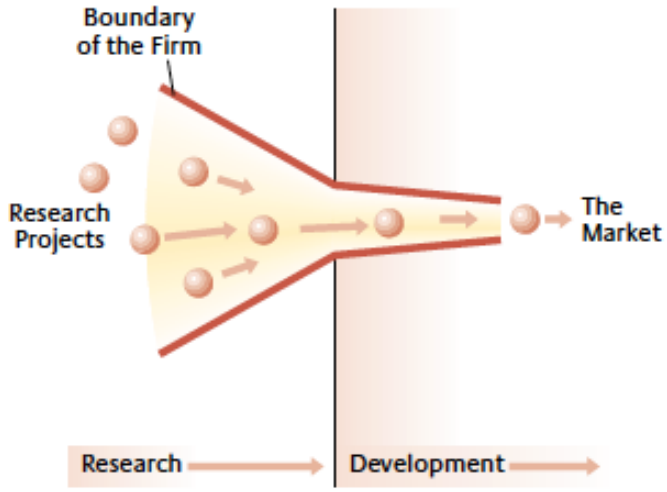


Figure 1. The Closed Innovation Model

In the past, entering a new market could be an impossible task for newcomers or small firms. The main barrier to entry was that the large corporations could, and did, afford to spend large sums on R&D, and hired the most talented people in their field. By dominating R&D, large firms also dominated markets. Newcomers had to invest heavily if they wanted a share of the profits. *Closed Innovation*, i.e. innovation which emanates from within the organization, meant that internal R&D was viewed as a strategic asset. This strategy has led to many important breakthroughs, which have changed the lives of many people around the world, for example DuPont invented Lycra and Nylon, and Bell Labs developed transistors and lasers. Firms protected their

intellectual property (IP) fiercely, using the profits generated from sales of the product to invest in more R&D, more innovation, and more profits, creating a cycle of innovation. This closed process does however not explain the upstarts who are entering markets and even dominating them.

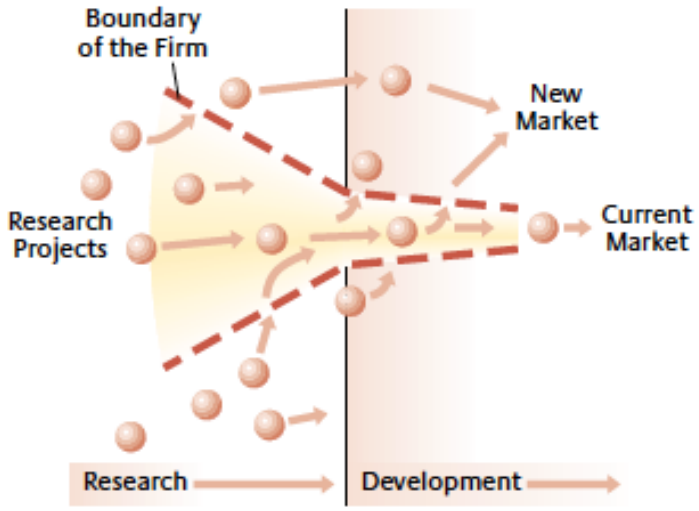


Figure 2. The Open Innovation Model

Henry Chesbrough, who coined the phrase *Open Innovation*, pinpoints two main changes which took place at the end of the 20th century, and which dramatically changed the way firms innovate. Perhaps most important, is that the number of knowledge workers increased, and became more mobile, with the result that it became difficult to control their ideas. This trend of mobility and change in relationships, identities, and business at large is known as liquid mobility (Bauman, 2000). Secondly, new firms began to receive financial help to enter new markets and develop their ideas from private venture capitalists. Ideas were being created outside the large corporate labs. This meant that the closed cycle of innovation was no longer the only option, nor the best option to dominate markets. Enterprises which engage in open innovation have alternative ways to enter markets and compete, in some cases with incumbents. Bauman wrote that in the era of liquid modernity, domination is not

about who is bigger and who is smaller, but rather who is quicker and who is slower. (Bauman, 2000). Speed is of the essence, and being bigger represents a liability.

It is more than likely that, within a firm, ideas may be generated which are of no use to the originating firm, but which may hold value for an outside firm. Open innovation enables these ideas to be explored and exploited outside the firm, through start-ups and licensing agreements. Ideas which may have been dismissed previously, within a closed innovation model, can now be shared with companies which can use and develop the idea. Open innovation strategies help firms to identify these options. Thus ideas which do not follow the firm's line of business can still be a source of value generation. Likewise, firms can also use external ideas to generate value, allowing the information to flow into the organization. Additionally, an open innovation strategy enables firms to identify ideas which are aligned with the business line, but which, in order to be exploited fully, need to be combined with external knowledge. As we can see, open innovation means that the firm is open to the external environment, during both the research and development stage. The boundary between the firm, external firms, and the market is porous. Although no firm can be completely open or even completely closed to innovation, it is paramount that firms who do engage in open innovation share their knowledge with the market (Chesbrough, 2003).

Structure

Given the importance of SMEs for the economy, the trend for Open Innovation in SMEs (Lee et al., 2010), and the consensus that there is a lack of research into Open Innovation in SMEs (Albors-Garrigós et al, 2011; Lee et al, 2010), this thesis is divided into the following logical chapters:

- Chapter 2. A methodical literature review entitled "*Open Innovation in SMEs: a research and review agenda."* This review comprises 99 peer-reviewed articles, spanning a decade, published on Open Innovation in SMEs. In the review I identify barriers to Open Innovation specific to SMEs, propose a framework for the classification of said barriers, and identify a research gap: namely the outcomes of Open Innovation in SMEs, or How to measure the results of open innovation in SMEs. A version of this chapter has received a second invitation for revision from the editor of a 1st quartile journal.
- Chapter 3. An empirical, quantitative study entitled "*Outcomes of Open Innovation in SMEs: The Impact of Intellectual Property Rights Strategies*". I answer the research gap identified in the literature review and broach the following question: *Is Open Innovation positively related to firm performance in SMEs?* Since Open Innovation implies collaboration between firms, a need to protect and profit from knowledge arises, in the form of Intellectual Property (IP). This chapter therefore analyses four key elements of IP: patents, industrial designs, trademarks and copyrights. I formulate hypotheses to test the relationship of each element of IP and firm performance in SMEs, and estimate the hypothesised effects with a series of random-effects regression analyses. I find that SMEs do not benefit from Open Innovation and patenting in the same was larger firms to. There is also evidence that SMEs profit in different ways from Intellectual Property Rights (IPR), depending on their size and the corresponding IPR. A version of this chapter is in the second round of revise and review of a Scopus 1st quartile journal.
- Chapter 4. A qualitative analysis entitled "*Social Media Practices for Open Innovation in SMEs"* which explores the case of a start up and its use of social media. Since the exchange of knowledge is essential to innovation, social

networks are increasingly playing an important role in open, interactive innovation. This chapter studies how social media is used to carry out Open Innovation in SMEs, and finds that the main advantages of the Web 2.0 translate into opportunities, challenges and strategies for open innovation. A version of this chapter has been accepted for publication in a Scopus 2nd quartile journal: *Journal of Business Strategy*.

Chapter 1: introduction	Aims	Research methodology	Main results
Introduction			
The Open Innovation Model			
Structure to the thesis			
Abstract Chapter 2			
Abstract Chapter 3			
Abstract Chapter 4			

Chapter 2: "Open Innovation in SMEs: a research and review agenda."			
Aim	A systematic review of literature published in Open Innovation in SMEs. 99 articles, spanning the years 2005-2014.	Literature review	SMEs face barriers which originate both within the firm: smallness, costliness, organisational and cultural; and outside the firm: institutional. The most frequent barriers are at an organisational/cultural level. These barriers are organised into a theoretical framework and classified them as either resource based or transaction-cost based, and as simple or complex. I demonstrate that literature gaps still remain, particularly regarding the outcomes of open innovation in SMEs.
Methodology			
Data analysis			
Results			
Outcomes of Open Innovation in SMEs			
Discussion			
Conclusions			

Chapter 3: "Outcomes of Open Innovation in SMEs: The Impact of Intellectual Property Rights Strategies"			
Introduction	This chapter studies the relationship between open innovation with IPR strategy in SMEs. For this, patents, industrial designs, trademarks and copyrights are considered.	Quantitative: 2,873 firms from the Spanish Community Innovation survey	A key result is that SMEs do not benefit from open innovation or from patenting in the same way larger firms do. Moreover, the results show that SMEs profit in different ways from IPR, depending on their size and the corresponding IPR.
Background and hypothesis development			
Methods			
Results			
Discussion and theoretical implications			
Managerial and policy implications			
Limitations and further research			

Chapter 4: "Social Media Practices for Open Innovation in SMEs**"**			
Why social media may revolutionise innovation Open innovation in SMEs The open innovation process at Aurea Productiva The open innovation ladder Social media challenges for open innovation Discussion and conclusion	This chapter studies how social media is used to carry out Open Innovation in SMEs, using the case of a start-up.	Case study: start-up Aurea Productiva	I explore how the main advantages of the Web 2.0 translate into opportunities, challenges, and strategies for open innovation that can be directly applied by managers.

Table 1. Structure of the contents of the thesis: aims, methodology and main results.

Abstracts

Abstract Chapter 2: "Open Innovation in SMEs: A research and review agenda."

Open innovation is receiving increasing attention, and research on this topic is now extending beyond large firms and encompassing SMEs. Still, several important areas remain under researched. By analysing literature spanning a decade, a systematic review of the literature published on open innovation in SMEs is undertaken, and the agenda for future research is set. When engaging in open innovation, SMEs face barriers which originate both within the firm: smallness, costliness, organisational and cultural; and outside the firm: institutional. This review indicates that the most frequent barriers are at an organisational/cultural level. These barriers are organised into a theoretical framework and I classify them as either resource based or transaction-cost based, and as simple or complex. Furthermore, it is demonstrated that literature gaps still remain, particularly regarding the outcomes of open innovation in SMEs.

The results derived from this literature review are wide-ranging and include insights into areas such as business organization and culture, governmental support, and IP protection. In addition, managerial implications are derived from the results regarding organizational culture, organizational inertia, employee motivation, etc. Furthermore, this review also includes recommendations which are of special interest to policymakers.

Abstract Chapter 3: "Outcomes of Open Innovation in SMEs: The Impact of Intellectual Property Rights Strategies"

This chapter studies the relationship between open innovation with IPR strategy in SMEs. For this, patents, industrial designs, trademarks and copyrights are considered. The relationships between open innovation, IP strategies, and profitability are tested with random-effects panel regressions on data for 2,873 firms during the years 2008-2013 from the Spanish Community Innovation Survey. A key result is that SMEs do not benefit from open innovation or from patenting in the same way larger firms do. Moreover, the results show that SMEs profit in different ways from IPR, depending on their size and the corresponding IPR. The very different impact of IP strategies on the efficiency of open innovation in firms of varying sizes highlights the importance of further investigation into IP strategies and into open innovation in SMEs. Industrial designs are currently the most efficient strategies for SMEs to protect their intellectual property in open innovation collaborations. Depending on the company size, different IPR strategies are recommended. Firms should seek to increase efficiency of open innovation and IPR strategies. The high impact of SMEs on employment highlights the importance of fomenting efficient innovation processes in such firms. This chapter opens the black box of IPR in relation to open innovation in SMEs, and draws different conclusions with respect to patenting, industrial designs, trademarks, and copyrights.

Abstract Chapter 4: "Social Media Practices for Open Innovation in SMEs"

The exchange of knowledge in social networks is fundamental to innovation. Open, interactive, innovation requires collaboration through social networks. This social networking is increasingly carried out across the Internet through social media applications. Still, we know little about the use of social media in open innovation, and less about how this practice is carried out in SMEs. With fewer resources than large firms, SMEs both have a greater need for open innovation and less to invest in the innovation process. In this chapter, I study the case of open innovation in start-up Aurea Productiva and induce a framework for open innovation in SMEs powered by social media. I explore how the main advantages of the Web 2.0 translate into opportunities, challenges, and strategies for open innovation that can be directly applied by managers. A contribution is made to research on open innovation by social media and to research on the innovation process of SMEs. Future quantitative research could confirm and extend the results. Companies that want to fully exploit the benefits of social media can create strategy that emphasizes coevolution of innovation and resources, sharing their vision and objectives, and providing a framework for innovation.

Chapter 2

Open Innovation in SMEs: A review and research agenda

The aim of this chapter is to undertake a systematic review of literature published on open innovation in SMEs, in order to identify the barriers to open innovation which affect SMEs in particular, the outcomes of open innovation in SMEs, and finally, to pose future avenues of research which may be fruitful. This topic is of great relevance, when we consider the impact of SMEs on employment and the wider economy, and that there is a research gap regarding open innovation in SMEs. Of the 99 articles analysed in this literature review, 40 are from 2013 and 2014, which suggests that this is an area of growing interest and warrants further investigation. The barriers, outcomes and avenues of further research I identify are wide-ranging and include insights into areas such as business organization and culture, governmental support, and IP protection.

Methodology.

In order to carry out this literature review, data was collected from articles published in academic journals with impact factor listed in Journal Citation Reports (JCR) of the Web of Science. An initial keyword search using the terms *SME "open innovation"* yielded only 7 articles. Expanding the search using the terms *"open innovation" AND "SMEs"* produced 10 more articles. Since these results mean that there is little published on open innovation in SMEs, I decided to adopt more wide-ranging keywords and synonyms for SMEs and Boolean search terms, searching for *"open innovation" AND family OR SMEs OR entrepreneur* OR "small business" OR family OR sme OR "start up*"*. A total of 99 articles (Appendix 1) have been selected for analysis based on the keyword search.

In addition to these articles, three seminal books on open innovation have been included: Open Innovation: the New Imperative for Creating and Profiting from Technology (Chesbrough, 2003) Open Innovation: Researching a New Paradigm

(Chesbrough, Vanhaverbeke, & West, 2008); and New Frontiers in Open Innovation (Chesbrough & Vanhaverbeke, 2014). These books were selected due to their important contributions for both practitioners and researchers, and the overview of developments over the last decade provided within.

Data analysis.

The articles were initially reviewed systematically using a spreadsheet, and the following elements selected for analysis: year of publication, journal, keywords, type (qualitative, quantitative, conceptual or review), main theories, further study, family business, sector, and data referring specifically to open innovation in SMEs. The results of this analysis were then categorized into logical groups.

An initial analysis of the articles selected for review supports claims of the increasing importance of the role in SMEs in open innovation (Lee, 2010) and the positive trend towards open innovation in SMEs (van de Vrande et al., 2009; Xiaobao et al., 2013). The earliest articles comprising this review date from 2005, and the latest from 2014. Using our selection criteria (figure 3), there is no research on open innovation published prior to 2005, following the original publication of the concept in 2003 (Chesbrough, 2003). Figure 4 shows the year of publication of articles on open innovation in SMEs, and illustrates the positive trend in interest in the topic. While 2010 marks the start of an increase in publications; there is a sharp increase in 2013. Of the 99 articles, 87 are from 2010 onwards, with 40 from 2013 and 2014. It should be noted that the data for this review was collected towards the end of 2014, and therefore not all research on open innovations in SMEs published in 2014 has been included in this review. The 99 articles which comprise this review therefore represent the most objective and influential research on open innovation in SMEs over a decade, spanning from 2005 to 2014.

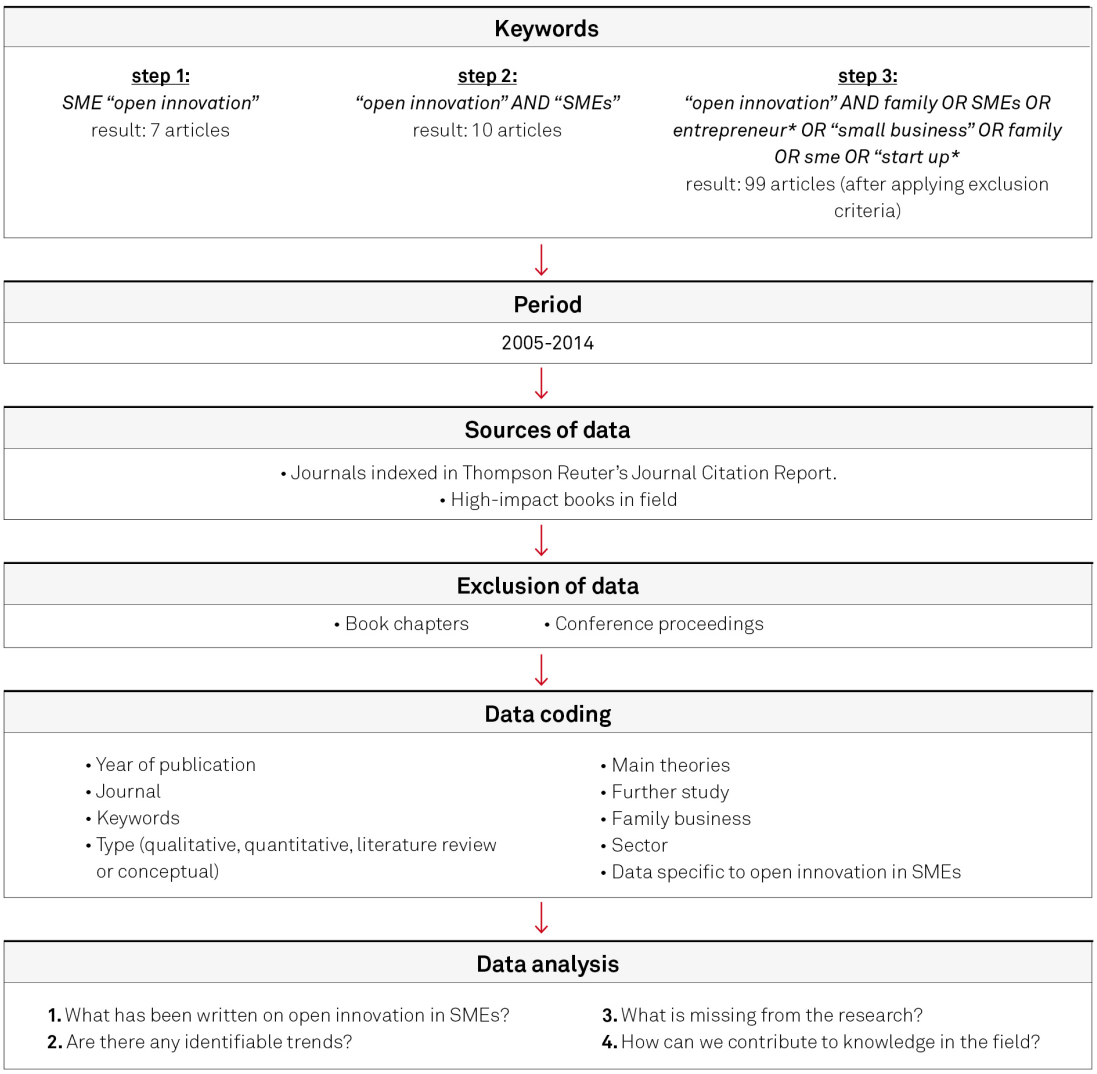


Figure 3. Summary of the literature review process

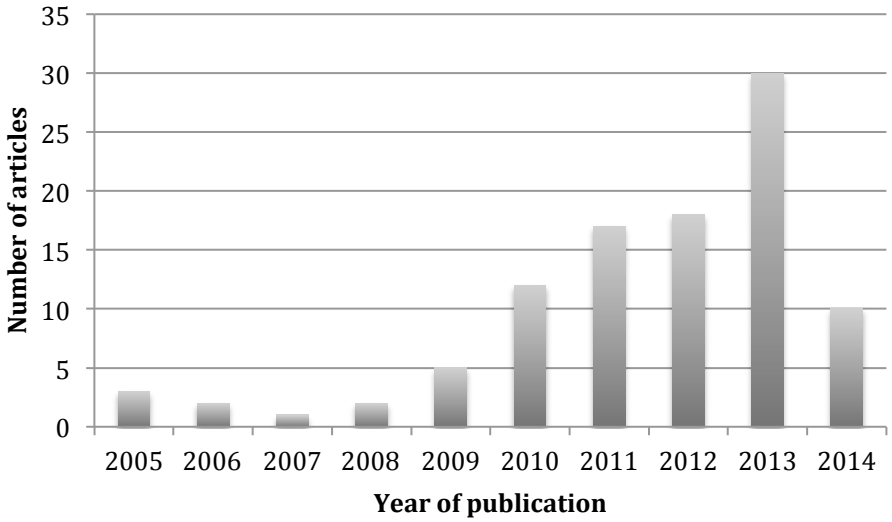


Figure 4. Year of publication of articles

The source of publication of the articles, as shown in figure 5, reveals that almost half of the articles which make up this review were published in seven journals: the International Journal of Technology Management being the most prominent with 10 publications. The other most significant publications are (in order of number of publications of articles included in this review) Technovation; the International Entrepreneurship and Management Journal; Research Policy; R&D Management; Research-Technology Management; and Technology Analysis & Strategic Management.

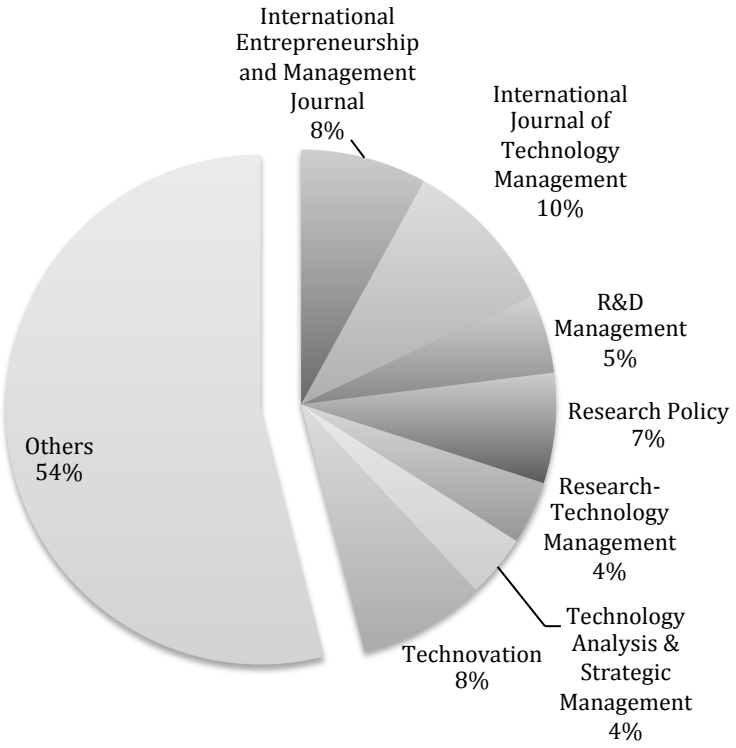


Figure 5. Distribution of articles by journal

Given that not all the articles on SMEs and open innovation were sector or country specific, my analysis of the literature has not enabled me to draw any conclusions on which sectors feature most prominently in research, or on how innovation differs in micro and small firms, compared to medium-sized firms. However, I have been able to detect that many of the firms which engage in open innovation are in high-tech sectors, such as biotechnology, space, telecoms, and software, to name just a few. In addition, research has been undertaken in firms which operate in a wide range of low-tech and service based sectors, such as wine making, hairdressing and aesthetics, and even internet dating.

As for the country of origin of the SMEs featured in the literature, table 2 provides an overview of the represented countries. Of the 99 articles included in this review, 68 specify which country, or countries, the SMEs engaging in open innovation operated

in. The majority of articles (53%) which were country specific studied SMEs based in seven countries: the Netherlands; Korea; Spain; Italy; Belgium; the US; and Denmark.

Freq.	Country
8	The Netherlands
6	Korea
6	Spain
5	Italy
5	Belgium
5	US
4	Denmark
3	Norway
3	United Kingdom
3	China
2	Germany
2	Slovenia
2	Hungary
2	Taiwan
2	Finland
1	Sweden
1	Austria
1	Poland
1	Scotland
1	Greece
1	Ireland
1	France
1	Peru
1	Estonia
1	Switzerland
68	TOTAL

Table 2. Country of origin of SMEs engaging in open innovation

After the initial analysis of the selected articles, I proceeded to carry out a more exhaustive review of the literature. This more in-depth analysis revealed the barriers that face SMEs when they engage in open innovation. The results also provide some insights for management and governments in order to overcome these barriers. Additionally, the data analysis has enabled me to pinpoint promising avenues of further research in the field of open innovation in SMEs, and suggest areas which may be beneficial to researchers.

Results

This review of the current literature on open innovation in SMEs has highlighted the many barriers faced by SMEs when engaging in open innovation. I categorise the barriers into those related to smallness, to costliness, to organization and culture, and to institutional factors. From these barriers implications are derived that may interest both managers and policymakers. Avenues of future research are also identified and presented in logical groups, phrased in open-ended question style in order to stimulate interest in the topic. Finally, I have detected a glaring research gap regarding how to measure the outcomes of open innovation in SMEs. This is a question which could also stimulate future research in the field.

Barriers of Smallness

SMEs can be defined according to the number of employees (less than 250) and turnover (less than €50m) or balance sheet total (net profit or loss less than €43m). SMEs are also further subdivided into micro, small and medium-sized (European Commission, 2014). Many firms fall into the smaller categories, and micro firms account for 29.1% of employment in the EU (European Commission, 2014), or 44% employment in SMEs (which represents 66% of employment in the EU). While the definition of SME is debatable and unsatisfactory, firms with less than 10 employees account for 29.1% total employment in the EU. Smallness could therefore be one of the most important liabilities, or barriers, to innovation in SMEs.

Smallness in itself presents many barriers to SME performance, which can be overcome with open innovation. Perhaps the most important effect of smallness is the

lack of resources in SMEs. This lack of resources has a domino effect on capabilities in manufacturing, distribution, marketing, R&D funding and ability to attract researchers (Lasagni, 2012; Lee, Park, & Song, 2009). These resources, or internal capabilities, are fundamental in turning an invention into a product or process (Lee et al., 2010). Smallness also has organizational implications, since SMEs often have a multidisciplinary shortage compared to larger enterprises (Bianchi, Campodall, Frattini, & Vercesi, 2010). It is not possible for a firm to possess all skill sets and knowledge, particularly SMEs, which are not able to create their knowledge requirements through their own internal resources (Kim & Park, 2010). Innovation requires varied skill sets, especially in industry-spanning innovation activities. Evidently, the smallness hurdle is more marked in micro and small firms.

Smallness also presents a barrier to entry into a new industry, as an SME entering a new industry would be unable to compete against larger existing competitors with established R&D activities and up-to-date knowledge of technical advancements (Gruber & Henkel, 2006). Attempting to break into a new market with existing competitors necessitates both human and financial resources, which are in abundance in larger firms, but in short supply in smaller, newer companies. The effect of smallness is also apparent in the SME's marketing abilities (Gruber & Henkel, 2006).

Open innovation provides the smaller firm with the opportunity to address its liability of smallness, such as limited financial resources and lack of manpower, and come up with new products and processes (Lee et al., 2010; Pullen, De Weerd-Nederhof, Groen, & Fisscher, 2012). Innovation performance in SMEs can be positively influenced by cooperation with outside organisations, such as R&D laboratories and universities (Pullen et al., 2012).

Barriers of Costliness

The costliness barrier is related to the liability of smallness, but it also implies other financial burdens. SMEs and new start-ups are at a disadvantage to larger firms as their limited financial resources mean they cannot fund their own R&D departments or research (Katzy, Turgut, Holzmann, & Sailer, 2013) Research also suggests that open innovation can be expensive, entailing high transaction costs (Christensen, Olesen, &

Kjær, 2005). Additionally, the financial costs of external advisors, such as legal or patent experts, can also hinder SMEs, given that they cannot usually afford to employ such experts directly (Eppinger & Vladova, 2013; Huang, Lai, Lin, & Chen, 2013). Therefore, the costs associated with open innovation are not just related to actual innovation. They start long before cooperation with outsiders, with the drawing up of contracts, IP protection, etc.

Barriers of Organisation and Culture

Although many barriers are related to the liabilities and barriers of smallness and costliness, there is another set of barriers, which are unique to every organisation, large or small. Organisational and cultural barriers affecting cooperation with external partners are the most important barriers to open innovation in SMEs (van de Vrande et al., 2009). Most SMEs are family owned, which means that strategic decisions are made by one or more family members. Such decisions are influenced by past decisions, leading to established routines and processes, stagnant organisations and ultimately, organisational inertia. Organisations affected by inertia are slower at reacting to changes in the environment, be they threats or opportunities (Huang et al., 2013). Slower reactions and longer response times leave the SME open to serious competition. However, decision making in family-owned SMEs is not just subject to organisational inertia. Given family members' vested interests in the firm, personal objectives can also interfere with decision making, so that decisions are not necessarily what is best for the firm, but what is best for the family members. This may result in less risky innovative changes (Lasagni, 2012). The entrepreneur/owner of an SME may be the creator and inventor of the enterprise at the beginning of the life cycle, but it may take a change of leadership, and consequently an outside vision, to commercialise the innovation (Harryson, 2008). Different management styles are required at different stages in the life cycle, taking into account the objectives of each stage. A scientific approach is appropriate in the early stages of inventions; an entrepreneurial vision is more suited to commercialisation, and a risk-adverse approach is required during the maturity stage (Kirschbaum, 2005). Organisational inertia is therefore unconducive to commercialising innovation. Taking an invention and turning it into a successful project, thereby creating value, requires a transformation and a change in mindset (Kirschbaum, 2005).

Cultural barriers can also encompass the cognition and behaviour of the entrepreneur. SMEs based in small countries are obliged almost immediately to expand their business operations abroad, due to competition or lack of demand in their home countries. Current research has confirmed the importance of a global mindset, with the internationalisation behaviour of firms differing according to their home country (Felício, Caldeirinha, Rodrigues, & Kyvik, 2013). This is also in line with research which has found that those firms with high understanding of cultural, strategic and technologic differences are the ones who innovate the most (Albors-Garrigós et al., 2011).

Employees also play crucial role in creating barriers to open innovation. Research has shown that long-standing employees have a negative effect on firm performance, and that newer employees do not (Lee et al., 2009). This implies that the newer the employees, the more motivated they are to perform at work.

Openness in the firm has an influence on performance and the decision-making process. While external openness can be described as "the set of activities carried out by firms to both gather information from and voluntarily reveal knowledge to the external world", internal openness can be described as "those carried out to encourage and support suggestions and change initiatives from below". Internal openness thus describes the culture of the organisation works, the relationships between members, behaviour, beliefs and opinions (Wu, Lin, & Chen, 2013). In short, internal openness refers to "the way we do things around here". In order to successfully engage in open innovation, firms must foster an organisation culture which is responsive to change, including both owners and employees, avoiding the "not invented here" syndrome. The organisational climate of a firm can have a positive or negative effect on knowledge sharing within a firm (Urbano & Turró, 2013). The amount of English-speaking employees in a firm is linked to more intense open innovation, namely relationships with suppliers (Dries, Pascucci, Török, & Tóth, 2014). This confirms the need to openly share information globally, in order to successfully innovate.

Not all cultural barriers to open innovation come from within the firm. They arise from interaction with other firms. The behaviour of alliance participants can also be an

innovation barrier in SMEs (Xiaobao et al., 2013). The alignment of the pace of innovation of different organizations may slow down or hinder innovation (Ellwood et al., 2016). Participants, for example researchers, may work to a different timescale, due to other commitments, and work in a different way, due to the corporate culture within their organisation (Padilla-Melendez, Del Aguila-Obra, & Lockett, 2012). Working with outside firms can raise issues of trust when dealing with IP protection. However, working with outside companies can introduce new mindsets and attitudes which can inspire the firm (Idelchik & Kogan, 2012). On the other hand, openness leads to dependence on external agents, so caution should be exercised (Holm, Günzel, & Ulhøi, 2013). The question remains whether engaging in open innovation and letting outsiders into the firm can be the catalyst to organisational change, thereby providing the firm with a tool to overcome inertia.

Barriers of Institutional Factors

As seen previously, many of the barriers to open innovation in SMEs are intrinsic, and derive from within the firm, as a result of liability of size, costliness, or cultural and organisation issues. Our review of the literature on open innovation in SMEs has also yielded a number of external factors of institutional nature. Vigier (2007) argues that Europe is at a disadvantage in terms of innovation, compared to the rest of the world due to inadequate knowledge creation, poor links between education and public R&D, and new policy developments (Vigier, 2007). The underlying cause could be due to inadequate governmental action, be it at a European, national or local level. Policy makers are a key part of knowledge creation, and play a pivotal role in policy making and shaping the institutional and legal framework in order to foster open innovation activities, since the success of open innovation depends on how easy it is to access external knowledge (de Jong, Kalvet, & Vanhaverbeke, 2010). Moving towards open innovation is complicated and firms need certain resources and abilities, including institutional support (Dries et al., 2014).

Policy makers need to be aware that the programmes designed to encourage open innovation work differently in SMEs and large firms, and that those designed for SMEs may not have significant effects on MNEs. SMEs and larger firms need different types of tactics in order to bring their inventions to commercialisation (Kang, Gwon, Kim, &

Cho, 2013). This may be due to the cumulative effect of the intrinsic barriers to open innovation in SMEs, which are different to those in large firms. Coupled with this circumstance is the characteristic that not all SMEs are high tech. Policy makers therefore need to design and implement policies which improve innovation in all SMEs, not just those operating in the high-tech sector. In fact, high-tech SMEs may not be quite as significant to the economy as imagined by policy makers (Brown & Mason, 2014). Policy makers have shown interest in open innovation models, but they are mostly applicable to medium and large enterprises, ignoring smaller firms (Albors-Garrigós et al., 2011). SMEs in low-medium-tech industries are also trying to increase innovative activities and performance as a way of overcoming Asian competition, which can be characterised by its low costs (Comacchio, Bonesso, & Pizzi, 2012).

Governments can foment open innovation in many ways. Following is a summary of the different measures suggested in the review of the literature. In the case of service SMEs, networking may not be an efficient way of boosting open innovation. In order to encourage open innovation in SMEs in this sector, policy makers should put into place policies which foster different activities (Suh & Kim, 2012). Institutions could help SMEs to access external knowledge by using government agencies and innovation hubs (Vrgovic, Vidicki, Glassman, & Walton, 2012). While this particular study focussed on SMEs in developing countries, these actions, when used in conjunction with others, could also spark innovation in SMEs in other countries. Collective research activities between firms with less absorptive capacity could also by publicly funded, with the amount of finance depending on the firms (Spithoven, Clarysse, & Knockaert, 2011).

While innovation policy may be challenging in terms of SME innovation strategy and motivation (Albors-Garrigós et al., 2011), it makes economic, and perhaps ethical, sense to open up knowledge which is going unused in firms. Policy initiatives such as publicly supported innovation intermediaries can help transfer key, economically-valuable knowledge and resources from firms, where they may remain unused, back to society (Clausen & Rasmussen, 2011). SMEs can play a key role in this process, but due to their resource limitations, public policy can support knowledge creation through technology transfer offices, business incubators, or entrepreneurship centres (Katzy et al., 2013). Using the public purse to fund innovation intermediaries, such as

incubators, is a more hands on approach, than compared to other publicly funded initiatives, such as tax breaks and grants for R&D (Clausen & Rasmussen, 2011). SMEs can unlock the information within large firms: it is probable that this information is more valuable to society, than it is to private firms. This also links in with inertia within companies, as an organisational barrier. Open innovation may therefore enable organisations, which suffer from inertia to make use of their knowledge. (Clausen & Rasmussen, 2011).

Governments also need to start implementing policies at a grass-roots level, by investing in education, both school and lifelong learning. Formal education is linked to entrepreneurship (Urbano & Turró, 2013), and lifelong learning can help employees move into new employment sectors (Mayer, 2010). Amongst other policies, Supporting R&D development, stimulating interaction between innovation actors, supporting the creation and survival of entrepreneurial companies, creating a strong science base and funding research, providing a supply of qualified labour to meet demands, and creating a flexible labour market are all ways in which governments can create the right conditions for open innovation to succeed (Mayer, 2010). As mentioned previously, firms with more English-speaking employees are linked to more intense open innovation (Dries et al., 2014). Governments therefore need to be proactive and provide future employees with the foreign language skills, which are indispensable to compete in the global market.

Finally, government intervention does not have to take the form of publicly funded activities to encourage innovation at the firm stage. Public policy can also begin by increasing entrepreneurial activities at a young age, and provide individuals with the necessary tools to become an entrepreneur. Creativity, risk-taking and independence are all factors that are associated with entrepreneurism, and people exhibiting these personality traits are more likely to become an entrepreneur, and not an employee (Knörr, Alvarez, & Urbano, 2013). Additionally, women are also constrained by socio-cultural barriers, namely “fear of failure” and “perceived capabilities”. Using positive female role models would perhaps inspire more women to become entrepreneurs (Noguera, Alvarez, & Urbano, 2013).

The economist Mariana Mazzucato writes about the State as a dynamic driver of innovation in her book The Entrepreneurial State: Debunking Public vs Private Sector Myths (Mazzucato, 2015). In her work, she questions the role of the public sector in fostering economic growth, and debunks the assumption the State comprises "lumbering, heavy-handed, and bureaucratic institutions" which hinder the private sector, while it is the "fast-moving, risk-loving and pioneering public sector" which is the driver of innovation behind economic growth. The common view is that the role of the State is to intervene to fix markets, but not to actively try to "create and shape them".

Through examples, she demonstrates how State investment can transform technology and create new markets. While private companies may be restricted to focusing on the bottom line, for example, energy companies invest in oil extraction, and pharmaceutical companies focus more on development of existing drugs and marketing, State investment can directly and indirectly invest in green companies by providing grants, tax breaks, and loans, while also stimulating demand and creating a market for products through tax rebates for consumers who have solar panels. In the case of the pharmaceutical industry, State investment can once again be direct, through investment into new drugs, or indirect, by funding work on diagnostics and lifestyle changes, to name but a few.

Excellent examples of how public investment can be a driver of innovation and growth, and take far bigger risks that the private companies who may be weighed down by their need to generate profit, are the Apollo project and the development of the iPhone. Mazzucato writes how it was the State which endeavoured to put a man on the moon, not private companies. In this sense the State should "*do things that are not even envisioned and therefore not done at all*". As for the iPhone, she writes how every single element which makes the iPhone *smart* was publically funded: from the Internet, to touch screen, and SIRI. This is not to downplay the crucial role of Steve Jobs and Apple Inc., but to show how the State can and does take risks, thereby shaping the technological landscape. Such risk taking, innovation, and thinking beyond our current capacities, actively shape a direction for change. The entrepreneurial state

is therefore willing to "invest in, and sometimes imagine from the beginning, new high-risk areas before the private sector does" (Mazzucato, 2016).

At first glance it would seem that the conclusions of this literature view are in stark contrast to writings of Mazzucato: I find that institutional barriers, i.e. the State, are a barrier to successful open innovation in SMEs, and Mazzucato holds that the State is a driver of innovation and change. However, the barriers (and needs) I identify are in line with Mazzucato's indirect State investment: poor links between education and R&D, and inadequate knowledge creation and new policy developments (Vigier, 2007); the need to put into place policies which encourage open innovation in SMEs (Suh & Kim, 2012) and to create access to external knowledge through government agencies and innovation hubs (Vrgovic et al., 2012); and tax breaks and grants for R&D (Clausen & Rasmussen, 2011). At a more fundamental level, the State can indirectly invest in innovation and growth by fostering creativity, entrepreneurship and risk-taking (Knörr et al., 2013); creating a strong science base and a qualified, flexible labour force (Mayer, 2010); and equip workers with the language skills necessary to compete in a global market (Dries et al., 2014).

Barrier	References	Key theories and concepts	Findings
Smallness	Bianchi et al., 2010; Gruber & Henkel, 2006; Kim & Park, 2010; Lasagni, 2012; Lee et al., 2009; Pullen et al., 2012	Open innovation; network theory; resourced-based view; knowledge-based view; absorptive capacity; dynamic capabilities; venture management; newness;	• SMEs lack resources, e.g. human and financial. • SMEs are less able to transform innovation into finished products. • They are less able to attract researchers. • They are likely to have a shortage of multidisciplinary knowledge. • They are unable to compete with larger firms in terms of R&D. • Cooperation overcomes the liability of smallness and therefore increases innovation performance.
Costliness	Christensen et al., 2005; Eppinger & Vladova, 2013; Katzy et al., 2013	Open innovation; IP management	• SMEs cannot fund their own R&D. • Open innovation can entail high transaction costs. • Other costs such as legal or patent experts can also prove to be an obstacle for SMEs, as they cannot usually afford to employ experts directly.
Organisation and Culture	Albors-Garrigós et al., 2011; Dries et al., 2014; Felício et al., 2013; Harryson, 2008; Holm et al., 2013; Huang et al., 2013; Idelchik & Kogan, 2012; Kirschbaum, 2005; Lasagni, 2012;	Open innovation; SMEs vs MNEs; internationalisation; network theory; creativity; entrepreneurship; organizational inertia; business model innovation; innovation management and leadership; family-owned business;	• Most SMEs are family owned, which increases risk for organisational inertia. • Successful innovation requires a transformation and a change in mindset. • Cultural barriers affect cognition and behaviour of entrepreneurs. • Internationalisation behaviour of firms differs according to home country. • Firms with high understanding of cultural, strategic and technologic differences innovate the most.

	Lee et al., 2009; Padilla-Melendez et al., 2012; Urbano & Turró, 2013; van de Vrande et al., 2009; Wu et al., 2013; Xiaobao et al., 2013	corporate entrepreneurship; resource-based theory; institutional economics;	• Organisational climate can have a positive or negative effect on knowledge sharing within a firm. • The more English-speaking employees in a firm, the more likely the firm is to engage in more intense open innovation. • Cultural barriers can arise from interaction with other firms.
Institutional factors	Albors-Garrigós et al., 2011; Brown & Mason, 2014; Comacchio et al., 2012; de Jong et al., 2010; Dries et al., 2014; Kang et al., 2013; Vigier, 2007	Open innovation; knowledge creation; sharing and innovation; regimes of appropriability; innovative capability; technology uncertainty; government support; technology policy, SMEs; outsourced innovation; boundary spanning	• Europe is at a disadvantage in terms of innovation due to inadequate knowledge creation, poor links between education and public R&D, and new policy developments. • The success of open innovation depends on how easy it is to access external knowledge. • Firms need institutional support, resources and abilities to be able to move towards open innovation. • SMEs and large firms need different tactics and programmes to commercialise their inventions. • Policy makers should not concentrate on just high-tech SMEs. Low-tech SMEs are significant to the economy. • Policy makers show less interest in open innovation models in smaller firms than in medium and large enterprises. • Low cost competition from Asia is causing SMEs in low-medium tech industries to increasingly engage in OI.

Table 3. Barriers to Open Innovation in SMEs

Outcomes of OI in SMEs

The question remains how to measure the effect of open innovation activities in SMEs. Literature does not converge towards one best way to measure the effect of open innovation in SMEs on firm performance. Padilla-Melendez et al. (2012) found that the best way to measure knowledge transfer and exchange is through measuring the market results of R&D projects. A closed innovation strategy can also positively affect financial outcomes (Lee et al., 2009). Opting for an open business model can lead to an increase in stock price. Firms which select an open business model which is similar to already existing business categories can enjoy a 3.2% premium on their stock price. Firms which chose a different type of open business model can see a 1.9% drop in their stock price, initially, but over time this may lead to an increase (Alexy & George, 2013) Adopting an open model which is similar to existing categories is therefore a way of increasing gains in the short term. In order to facilitate the free flow of ideas and knowledge between innovation partners, firms may need to change their business model. This can increase performance, and free up ideas which are not being

exploited. By adopting new business models, firms can increase customer value and compete more effectively, therefore enhancing firm performance (Huang et al., 2013).

Both small and large firms can enhance performance and turnover by patenting their products, which shows that innovation can lead to an increase in turnover. Value creation, in terms of higher profit margins, can be achieved by patenting activities, by both SMEs and large firms. Small firms undertake less patenting activities, but when they do adopt this strategy, it leads to positive gains in innovation and profits. The managerial implication is that SMEs should adapt their innovation strategy to include patenting activities (Andries & Faems, 2013). Given the financial constraints on SMEs, it suggests that the benefits of patenting in terms of turnover generation can outweigh the costs associated with patenting, for example, legal costs. However, open innovation strategy is firm specific, and needs to take into account the idiosyncrasies of the firm. Patenting activity, as an extension of open innovation, should also be adapted to the unique needs of the firm.

Finally, current literature also suggests that adopting a closed innovation approach can also make financial sense in family-run SMEs. Measuring operating profit in family-run SMEs, Lee et al., 2009, found that an open innovation strategy did not affect the operating profit ratio. Family control as a closed innovation strategy on the other hand did. Closedness was measured by total family ownership as a percentage, other family businesses joined to family ownership, family members as CEO, and if the business was handed down through the generations. This raises important questions, as some sectors and enterprises may benefit more from an open innovation strategy, i.e. high R&D, a greater need to cooperate with outside agents, and a high number of inter-industry patent applications. However, family-run SMEs, with a closed hierarchy, can benefit more from a closed innovation strategy. This is line with previous findings about the need to select an innovation strategy which is suited to the firm's requirements. While the sample in this study was small, and limited to a specific geographical region, it was the only study in the literature which focussed on family-run SMEs. Family run SMEs are a significant part of the economy: in Europe most SMEs are family owned, and family-owned firms account for 60% of all firms, whether micro, small, medium or large (European Commission, 2015).

Discussion

The review of the research published open innovation over a decade reveals that this is a topic that remains under researched. I identify several areas of study which may perhaps spark further research in the future, and a research gap in the field of open innovation in SMEs: that of the outcomes. Additionally, a classification of the barriers faced by SMEs when adapting an open innovation strategy is provided. After analysing these barriers, a series of measures to be taken by managers and policymakers to overcome these barriers is proposed. The barriers refer to smallness, costliness, organisation and culture, as well as institutional factors, which affect the uptake of open innovation in small firms.

Smallness is a significant barrier, since SMEs, due to their nature, lack resources to compete with larger firms in terms of manufacturing, distribution, marketing and R&D funding (Gruber & Henkel, 2006; Lasagni, 2012; Lee et al., 2010). They lack the internal capabilities to complete the cycle of innovation alone, meaning that they are more susceptible to sharing knowledge and technology (Bianchi, Campodall, Frattini, & Vercesi, 2010; Lee et al., 2010). SMEs suffer from a lack of the essential elements for breaking into new markets: human and financial resources. They are also unable to compete with incumbent larger firms in terms of R&D activities and technological developments (Gruber & Henkel, 2006).

The second barrier I identify is costliness, which is indirectly related to smallness. Smallness translates into limited financial resources, so that funding R&D departments or undertaking research may be beyond their financial abilities (Katzy et al., 2013). Open innovation also entails high transaction costs, and other more indirect costs, such as legal or patent experts (Christensen et al., 2005; Eppinger & Vladova, 2013; Huang et al., 2013). Such costs can prove to be an obstacle for SMEs.

It is clear, that in terms of quantity, the most important barrier to open innovation in SMEs comes from within the firm, and is a result of organisational and cultural factors. It can therefore be argued the key to successful open innovation in SMEs may be a leadership issue. Managers and/or owners should allow new mindsets and attitudes to

flow into the organisation from outside firms, despite the trust issues this can raise (Idelchik & Kogan, 2012). Openness can mould the internal culture of a firm, fostering change in the organisation. Family-run SMEs can suffer from organisational inertia, less risk taking, and stagnant organisations as a result of their decision-making process (Lasagni, 2012). Finding ways to overcome organisational inertia will play a significant role when family-run SMEs adopt open innovation. A change in mindset and the management process may be needed, with managers recognising that different management styles are needed at different stages in the innovation cycle, as each cycle has different objectives (Harryson, 2008; Kirschbaum, 2005).

Another, perhaps more delicate, challenge for managers is found in the barrier to open innovation resulting from employee behaviour. Long-standing employees may hinder innovation and change since they can have a negative effect on firm performance (Lee et al., 2009). This raises questions of a managerial nature, and how managers can continually boost motivation and morale within the workforce. Additionally, the internationalisation behaviour of firms is also a significant factor in open innovation, and such behaviour is connected to the home country of the firm (Felício et al., 2013). This could also be linked to the fact that the more English-speaking employees in a firm, the more likely the firm is to engage in open innovation (Dries et al., 2014). The firms which understand cultural, strategic and technological differences are those which innovate the most (Albors-Garrigós et al., 2011). Managers from countries which don't engage in internationalisation behaviour can overcome this barrier through personnel recruitment, selecting candidates with English-speaking skills, and an international outlook. The implications for management are varied, but it is clear that the most important barrier to open innovation in SMEs is a result of the culture of the organisation. Managers must thus promote the inflow of new mindsets, ideas, attitudes and routines in order to avoid organisational inertia and facilitate openness within the organisation.

The next set of barriers identified in this literature review is institutional barriers. Since it has been shown that Europe is at an innovation disadvantage in terms of inadequate knowledge creation, poor links between education and public R&D, and new policy developments (Vigier, 2007), policymakers should be urged to provide institutional

support in order to be able to move towards open innovation. The success of open innovation depends on how easy it is to access external knowledge (de Jong et al., 2010). Policymakers are currently more concerned with open innovation in large firms (Albors-Garrigós et al., 2011), but it is argued that SMEs deserve special attention when creating policies to promote open innovation. This is especially relevant as SMEs and large firms need different tactics and programmes to commercialise their inventions (Kang et al., 2013). Low cost competition from Asia is causing SMEs to engage in open innovation, especially those in low-tech industries (Comacchio et al., 2012).

Institutional support can help SMEs overcome other barriers, such as smallness, in the way of financial support, which would help them break into new industries, attract new researchers, and commercialise their inventions; and promote specific policies aimed at SMEs (in particular low-tech industries), thus recognising their important role in the economy. Organisational and cultural barriers can be overcome with institutional help. Investment in education at all stages of life creates a qualified, flexible labour force, which can meet the requirements of open innovation. Another important policy area is that of promoting the entrepreneurship of women, and breaking down the socio-cultural barriers that may constrain women, thus freeing up their entrepreneurial skills and bridging the gender gap in business.

In order to better understand these barriers, I categorise them in a theoretical framework as outlined in figure 6.

	Resource based	*Transaction-cost based*
Simple	Barriers of smallness	Barriers of costliness
Complex	Barriers of organisation and culture	Barriers of institutional factors

Figure 6. Framework of barriers to open innovation in SMEs

The barriers are classified as either resource based or transaction-cost based, and either simple or complex.

Transaction costs reduce the efficiency of transacting with other firms, particularly in situations of uncertainty (Coase, 1937; Williamson, 1979). As transaction costs decide whether firms locate activities within or outside firm boundaries, they also determine whether firms engage in open or closed innovation (Keupp and Gassmann, 2009). Innovation is a process that involves uncertainty (Nelson and Winter, 1977), and transaction costs are therefore considerable.

The resource-based view of the firm however argues that the competitiveness of each firm is determined by the set of resources to which it has access (Wernerfelt, 1984; Barney, 1991). Obtaining access to specialized, complimentary, assets is then a prime reason for engaging in inter-firm relationships regarding innovation (Teece, 1986). Since the focus of this study is on small and medium-sized enterprises, resource constraints can be expected to constitute important barriers, as described below. From the resource-based view, smaller firms are good objects of study because of their often less complex resource sets (Lockett, et al. 2009). Understanding resource-constraints faced by SMEs could thus further wider open-innovation research.

I also categorise the barriers to open innovation as either simple or complex, since complexity as a function of technological and organizational interdependencies is a contingency that significantly influences the organization and management of innovation (Tidd, 2001), and open innovation is more complex than its closed counterpart as it includes many more activities (van de Vrande et al., 2009). Complex systems consist of a large number of parts connected by nonsimple interactions (Simon, 1962). Thus, whereas the impact of simple barriers on open innovation can be expected to follow simple heuristics, the effects of complex barriers are more difficult to assess due to the unknown nature and magnitude of interactions between factors (Ethiraj and Levinthal, 2004).

Barriers of smallness and costliness indicate a lack of resources to engage in open innovation. These barriers are described as simple, since they depend on only a few variables, i.e. size or transactions, and identifying and understanding their effects on

open innovation is straightforward. SMEs need to build their competitive advantages on resources and capabilities just as do larger firms (Barney et al., 2001). However, SMEs have less access to both resources and capabilities due to their reduced size. Research suggests that open innovation is useful to SMEs, even more than for large firms, and that under certain conditions small firms engage in open innovation more intensively than large counterparts (Spithoven, Vanhaverbeke, & Roijakkers, 2013). Open innovation gives small firms access to resources otherwise unavailable to them (Lee et al., 2010; Pullen et al., 2012). Still, as has been established, smallness also impedes the SME to create the capabilities necessary for fruitful open innovation. These capabilities are often organizational and cultural (van de Vrande et al., 2009).

Whereas the resource-based barriers to open innovation are considerable, the costs involved when working with other companies lead to additional barriers. Any transaction between two firms imply additional costs (Williamson, 1979). The barriers of costliness are likely to be related to high transaction costs, particularly when working with larger firms (Christensen et al., 2005). Efficient institutions could help reduce transaction-related barriers (Williamson, 2000). From this review, it appears such efficient institutions are not yet in place to facilitate SME open innovation, and institutional factors thus remain a salient barrier for these smaller firms. Policy makers need to create knowledge and links between education and R&D, and foster open innovation by facilitating access to external knowledge providing institutional support (de Jong et al., 2010; Dries et al., 2014; Vigier, 2007). Research has shown that policy makers seem to be more interested in open innovation models that are applicable to large firms, not SMEs (Albors-Garrigós et al., 2011). SMEs need different types of tactics when commercialising their inventions (Kang et al., 2013). However, not all SMEs are high-tech, and their importance to the economy may be been overestimated by policy makers (Brown & Mason, 2014). Research indicates that low and medium-tech SMEs are overcoming low-cost Asian competition by increasing innovative activities and performance (Comacchio et al., 2012).

The organisational and cultural, and institutional barriers are defined as complex, since we cannot pinpoint the exact factors which constitute barriers to open innovation in SMEs: rather, it is a combination of interrelated factors, coupled with the unique

characteristics of each SME, which influence their successful uptake of open innovation.

The tension between lacking resources to engage with other firms on one hand, and high costs for inter-firm transactions on the other, indicates the importance to SMEs of an efficient open innovation process. We hence need to know under which circumstances open innovation is efficient and profitable in these firms. According to this review, current research does not solve this conundrum. There a research gap remains regarding the measurement of the outcomes of open innovation in SMEs. As we have seen, there seems to be little consensus on how to best measure the effect of open innovation in SMEs, and there certainly is no suggestion in the review of a one-size-fits all measurement. One possibility is using patenting activities: we have learned that patenting products leads to an increase in turnover in both large and small firms. However, large firms can afford to invest in many innovation projects, whereas SMEs may wage everything on one single innovation. Therefore, outcomes in SMEs need to be measured differently to those in large firms. One way of measuring the outcomes of patenting activity would be to look at the frequency or number of patents held by SMEs and large firms. Large firms tend to patent all inventions and use them strategically, to bargain with other firms. On the other hand, small firms patent only those innovations which are likely to be profitable (Spithoven et al., 2013). Innovative SMEs are less likely than large innovative firms to patent their innovations, but when they do engage in patenting, this activity has a positive effect on firm performance, both innovative and financial, in the long run, just like larger firms (Andries & Faems, 2013). Furthermore, we do not know under which circumstances SMEs benefit from an open innovation strategy, for example, if the benefits related to overcoming barriers are larger than the transaction costs.

The review of the current literature has also helped me to suggest directions for the future of research in the field of open innovation in SMEs which are outlined in table 4. By far the majority of avenues identified concerns the *organisational and cultural barriers facing SMEs*, which is in line with the large number of barriers detected in this area. Other avenues of research which could prove to be fruitful are the *mechanisms of open innovation*, or more specifically, how SMEs engage in open innovation; the

scope of open innovation in SMEs; *IP issues*; *institutional barriers facing SMEs*; and the *antecedents of open innovation in SMEs*: why firms engage in open innovation, and what challenges they face. While future research could point in any direction, one glaringly obvious research gap remains: how can the effect of open innovation on SME performance be measured? Current research has broached the subject, but there is no consensus as to how to quantify open innovation in SMEs. The implications of a study of this kind would help SMEs to decide whether their firm would benefit from engaging in open innovation, which strategy would best suit the firm according to its needs, and what the outcomes would likely be, enabling them to incorporate strategic open innovation activities. Such studies would also help fill the general research gap concerning the performance implications of inter-firm collaborations for innovation (Keupp, Palmié, & Gassmann, 2012). Another area which has not been fully explored is that of open innovation in family-run SMEs. It would be interesting to study how decision making and family involvement affect the uptake and outcomes of open innovation in family-run SMEs.

Area	Reference	Avenue
Smallness barriers facing SMEs	Spithoven, Vanhaverbeke, & Roijakkers, 2013	• How does size relate to the challenges posed by OI? Are smaller firms more challenged then medium-sized firms?
Organisational/Cultural barriers facing SMEs	Bocken et al., 2014; Felício et al., 2013; Noguera et al., 2013; Saguy & Sirotinskaya, 2014; Spithoven et al., 2013; Urbano & Turró, 2013; van de Vrande et al., 2009; Wincent, Anokhin, & Boter, 2009; Wu et al., 2013; Wynarczyk et al., 2013	• How can partner firms affect open innovation requirements, for example, in terms of culture, structure and decision making, with larger/smaller firms, and from different industries? • How can SMEs benefit fully from OI without becoming too dependent on external sources? • What are the individual characteristics of workers who are a source of OI? • How can management adapt to meet OI challenges, change in mindset and strategies? • How do managerial capacity and human skill affect the successful adoption of OI? • How do entrepreneurial personality traits, characteristics, motivations, and orientations determine how a firm engages in OI? • What role do OI practices play in internationalisation strategies of SMEs? • More qualitative research into how OI is influenced by organisational culture, interactions, interests, and relationships. • How does the global mindset of both the entrepreneur and corporation affect OI activities and internationalisation? • How does absorptive capacity (e.g. human capital and skill) affect the openness of firms? • Why do firms embrace openness? • What is the optimal level of renewal of board members in Corporate Venture Capital networks for effective R&D management? • What are the environmental, organisational and individual factors for corporate entrepreneurship? • How does family role affect female entrepreneurship?

Institutional barriers facing SMEs	de Jong et al., 2010; Saguy & Sirotinskaya, 2014; Urbano & Turró, 2013	• How can governments help create ecosystems which support OI and innovation sustainability? • Could institutional factors moderate intrapreneurship? • Which governmental structures can align and integrate policies for OI in different policy areas? • How are globalisation and optimum levels of policymaking connected?
Mechanisms (How do SMEs engage in OI?)	Kim & Park, 2010	• How do SMEs' OI activities compare with those of SMEs in other countries? • What exactly is mean by collaboration (e.g. networking, cooperation)? • How do firms use open innovation during growth phrase of innovation, and what are the managerial implications? • Can an innovation strategy be defined for SMEs, taking into account individual characteristics? • How can OI success be measured with metrics? • Is a business-like approach related to high innovation performance, in the case of new product development? • How do entry barrier evolve during the different phases of innovation? • What are the differences in collaborative activities between manufacturing and service sectors, in terms of tangible and intangible products?

Table 4. Avenues of further research of Open Innovation in SMEs

Conclusion

When it comes to open innovation, and in particular the new era of open innovation, what is important is the combination of players and strengths. In some cases, the weaknesses of a firm can be a source of strength when combined with another firm. This ties in with the idea of mutualism, or the mutualistic business model, whereby the symbiosis of different parties is beneficial for at least one party. Instead of thinking in terms of the barriers to open innovation, SMEs should think of their reduced size and unique culture as assets. In a mutualistic relationship between SMEs and large firms, both players bring something to the table. Large companies can furnish access to "resources, expertise, mentoring and facilities" that SMEs may lack. On the other hand, SMEs can help large firms stay relevant by providing "enthusiasm, new networks and up-and-coming talent, and the cool factor" (Prosise, 2014). Symbiotic business relationships are about solving problems, even when it looks like one partner benefits more than the other, or has to sacrifice a lot in order to reap the rewards of such a relationship (Sagarin, 2013). Possible forms of mutualistic business models include group collaboration on a shared challenge, pre-competitive collaborations, sponsored innovation incubators, relationships between large firms and startups, and prizes for innovative solutions to shared challenges (Prosise, 2014). Despite not being within the

scope of this thesis, it would also be interesting to define what, if any, role Mazzucato's Entrepreneurial State can play in a mutualistic business network.

Despite not expressly discussing globalisation, this literature review identifies a link between globalisation and open innovation. A global mindset and orientation can have an effect on the internationalisation behaviour of the firm, depending on the country of origin (Felício et al., 2013). This lends weight to the notion of a global mindset as an element of open innovation. Additionally, research has found that the more English-speaking employees in a firm, the more likely the firm is to engage in open innovation (Dries et al., 2014). Given the increasing amounts of international trade, an ever greater dependence on a global economy, and economic unions resulting in freer movement of goods, services and capital, investigating the relationship between globalisation and open innovation would make for a very interesting future research line.

Creativity, knowledge and entrepreneurship are the foundations of the innovation economy, which requires interaction between science and business ideas at an early stage. The combination of science and market, interacting with different sectors at different stages of the innovation cycle, means that the time from product development to market is shortened. The result is the creation of economic and social value that increases as the circle of innovation is reinforced (Berkhout, Hartmann, van der Duin, & Ortt, 2006). Considering the impact that SMEs have on the economy, the important role they play in generating revenue and employment, and the upward trend in open innovation in SMEs, this is a fascinating and fertile area for future research.

Chapter 3

Outcomes of Open Innovation in SMEs: The Impact of Intellectual Property Rights Strategies

Introduction

Nowadays the question is no longer if open innovation is important for a company, but rather to what extent. Herskovits, Grijalbo and Tafur (2013) state that innovation is "the single most relevant element in fuelling corporations' competitive advantage and ultimate value creation", and that it is open innovation which creates new "drivers for value creation". At the same time, such collaborations also lead to a need for knowledge protection through Intellectual Property (IP) so that companies can profit from these collaborations (Bogers, Bekkers and Grandstrand, 2012), as there seems to be no automatism for the use of open innovation to raise firm performance (Schuster and Brem, 2015).

Multinational companies explore the boundaries of open innovation extensively, but small and medium-sized enterprises (SMEs) are also catching up. This is important since SMEs represent a significant part of companies in the European Union, and also in other regions like Northern America. In fact, SMEs make up more than 99% of all businesses in the European Union, Japan and the United States (European Commission, 2014), and they are drivers of growth and innovation in economies (Eppinger and Vladova, 2013). During the recent economic downturn, it has been SMEs which have weathered the storm, and not their larger competitors (European Commission, 2014). In addition, SMEs are even more likely to apply for Intellectual Property Rights (IPR) than large firms (Jensen and Webster, 2006).

SMEs are becoming more and more involved in global markets and competition, compared to the early years of globalisation. This implicates a higher need for protection of products, as the threat of competitors and substitutes is potentially worldwide. Even in markets like China, which traditionally has had a low regime of

appropriability, the importance of IP protection seems to be gaining momentum, as local companies start to protect their products from imitation. This is illustrated by the high growth rates for patent and trademarks applications: China is number 1 worldwide (WIPO, 2015). Moreover, dealing with IP protection has increased in importance within the firm and has moved from being a specialized legal department task to the office of the Chief Executive Officer (Hanel, 2005).

Before this background, I analyze the impact of IPR strategy on the relationship between open innovation and firm performance measured as turnover. Earlier research indicates that SMEs do not make use of alternative protection titles beyond patents (Burrone, 2005), even though IP has a strong impact on market leadership and the overall performance of a company (Bollen et al., 2005). Hence, this analysis also explicitly approaches other forms of protection such as copyrights, industrial designs and trademarks.

For this reason, the case of Spanish SMEs is used, since they have been the most successful in obtaining funding from the SME instrument of the European Commission, a fact which is attributed to the vibrant SME network of this country (EASME, 2016). Recent investment projects and SME financing agreements are evidence of the increasing importance of Spanish SMEs for the Spanish and European economy (European Commission, 2016). In spite of the dynamic SME scene, Spanish firms in general do not collaborate as much in innovation as do firms in other EU countries (Guimón and Salazar-Elena, 2015). It is therefore especially important to understand how IPR may help or hinder these collaborations in Spain. The level of Spanish IPR is on par with some of the most advanced countries in this aspect e.g. Denmark, Germany, UK, and Japan, and is second only to those of the US and Ireland (Liu and La Croix, 2015).

This chapter is organized as follows. First, I give an overview of the relevant literature on IPR in SMEs and derive the hypotheses. Then the methodology and sample of Spanish SMEs is described. The results overview leads into the discussion section, where these results are discussed before the background of earlier research. Finally, the limitations of the research are shown, as well as future research paths.

Background and hypothesis development

IPRs are temporary monopolies to ensure and foster investments in innovation (West, 2006). "IP refers to unique, value-adding creations of the human intellect that results from human ingenuity, creativity and inventiveness" (Kalanje, 2006, p. 1). This chapter is bound to this definition of IP through the consideration of four key IP elements, namely patents, industrial designs, trademarks and copyrights. Before discussing the literature in these areas, a brief overview on the linkage between open innovation and firm performance is given, as earlier research indicates a relationship between IP and firm performance (Bollen et al., 2005).

The relationship between open innovation and IP protection is characterized through a paradox, where the question is if appropriability enforces or impedes open innovation. On the one hand, companies need to consider adequate protection before engaging with external actors to prevent unwanted knowledge spillovers. This is typically solved through the application of IP protection rights. On the other hand, there is only a limited defensibility of such rights in juridical disputes. In addition, competitors may simply find ways to bypass the secured areas, etc. Hence, a balanced approach is needed where regimes of appropriability are carefully analysed and adapted to the companies' strategy in order to control and manage access to knowledge (Laursen and Salter, 2014). In the context of SMEs, Jensen and Webster (2006) state using and enforcing IPRs is especially challenging because of a lack of financial resources and enforcement abilities. Since this discussion goes beyond the scope of this chapter, I would like to refer to related research in this area for further discussion of this paradox (e.g. West, 2006; Chesbrough, 2006; Belberos et al., 2010; Michelino et al., 2015).

Open innovation and firm performance in SMEs

While much has been published on open innovation in large, multinational firms, there has been less interest in open innovation in SMEs. In addition, the role of SMEs in open innovation is increasing (Brunswicker and Vanhaverbeke, 2015), and a positive trend towards open innovation in SMEs has been observed (van der Vrande, de Jong, Vanhaverbeke and de Rochemont, 2009). In general, earlier research indicates that

open innovation is positively related to firm performance. Pullen, De Weerd-Nederhorf, Groen and Fisscher (2012) state that cooperation with outside firms is linked to innovation performance, and particularly in the case of SMEs. SMEs can use open innovation to overcome barriers which result from their size. Huang, Lai, Lin and Chen (2013) find that business model innovation is positively linked to firm performance, and can help to overcome organizational inertia. Given the pivotal role played by SMEs in the economy, both at a national and European level, and the increasing importance of open innovation in SMEs, research into open innovation in SMEs is correspondingly of increasing importance. Further research into this field should present practical implications, of use to both practitioners and academics.

Research which has been published on open innovation in SMEs has analysed the difficulties they face when engaging in open innovation. Many of these difficulties can be categorized into, for example, a lack of funding (Spithoven, Vanhaverbeke, and Roijakkers, 2013), or a lack of resources, which in turn affects manufacturing, distribution, marketing, and R&D capabilities, or recruitment of researchers (Lasagni, 2012; Lee, Park and Song, 2009). These difficulties are a direct result of the reduced size of the organization. Other difficulties are also a result of the size of the organization, albeit indirectly. Costliness describes the financial burdens facing SMEs, such as being unable to finance research or in-house R&D departments (Katzy, Turgut, Holzmann and Sailer, 2013). Open innovation can also prove to be expensive (Christensen, Olesen and Kjær, 2005) and SMEs are rarely able to afford the direct employment of legal or patent experts (Eppinger and Vladova, 2013), and will need to look outside the company for professional advice when engaging in open innovation activities (Huang, Lai, Lin and Chen, 2013).

What has not been satisfactorily addressed to date is the effect of open innovation on SME performance with comparative studies (Seo, Chung, Chun and Woo, 2015). Some studies have broached the subject, but the evidence is rather scarce, not timely, and is somewhat conflicting. For example, Hung and Chiang (2010) established that a proclivity towards open innovation positively affects firm performance, whereas Spithoven, Vanhaverbeke and Roijakkers (2013) hypothesize that open innovation has a different impact on firm performance for SMEs compared to large firms, but find no

support for this difference in their Belgian data. Kim and Park (2010) found that not all open innovation activities have a positive effect on firm performance, and Lee, Park and Song (2009) stated that a closed innovation strategy can have a positive effect on performance, using operating profit ratio as an indicator of performance. Despite using a small data set, this study established that it may be in the best interests of SMEs to pursue a closed innovation strategy. Adries and Faems (2013) undertook research into patenting and firm performance, but use data from 2005, recognising in the limitations of their research that it is important to study patenting and licensing with more recent data. In their study into the effects of open innovation on performance of SMEs, Kim & Park (2010) suggest further research into open innovation activities of SMEs in other countries. Morata et al (2013) recommend a clear definition of the metrics of open innovation in order to compare the different types of open innovation, and to measure their success. From the literature reviewed, I consider that there is both a lack of research into open innovation success in SMEs and a lack of consensus. Although the empirical evidence is scarce and conflicting, authors hypothesize positive effects based on theory. I therefore formulate and test the following hypothesis.

Hypothesis 1: Open innovation is positively related to firm performance in SMEs.

Innovations from SMEs come in many cases from an informal nature, where industrial designs, trademarks and copyrights play a key role to ensure a competitive advantage – beyond patents. These rights give SMEs the opportunity to differentiate themselves from competition with an exclusive right of using a mark or a design (Burrone, 2005). Hence, this analysis covers patents, industrial designs, trademarks and copyrights.

Intellectual Property Protection and SMEs: Patents, industrial designs, trademarks and copyrights

Patents are the most common used IP right, but SMEs often neglect using them (Thomä and Bizer, 2013). Research indicates that IP protection through patents is positively related to performance in terms of commercialization success (Andries and Faems, 2013). However, having many patents does not automatically lead to high sales performance (Agostini, Caviggioli, Filippini and Nosella, 2015). Some studies have broached the subject of patenting activities in SMEs, and have linked it to performance.

Hanel (2006) states that SMEs have higher patenting rates, but larger companies generate more patents per firm. Andries and Faems (2013) found that both large firms and SMEs can use patenting strategies to increase turnover. Despite finding that patenting is less frequently employed in innovative SMEs, the results of their study showed that when patenting is used in SMEs, is has a positive effect on "innovation and financial performance". These findings suggest that large firms and SMEs need to use different strategies for patenting when engaging in open innovation. This is in line with Spithoven and his colleagues (2013), who state that SMEs differ to large firms in their patenting activities since they patent only the innovations that are likely to be successful. Given the increased resources and personnel of large firms, they are able to patent all their innovations: SMEs, however, face financial and organizational barriers, which impede systematic patenting. Spithoven et al. (2013) encourage further study into the specifics of open innovation in SMEs. Kalanje (2006) writes that the barrier of costliness and lack of resources are reasons why SMEs patent less than large firms, and that the patenting process can hamper innovation, but when used befittingly, it can be a source of revenue and consequently affect firm performance. Eppinger and Vladova (2013) affirm that "resource shortages" and "lack of Intellectual Property management practices" are some of the barriers faced by SMEs. It can therefore be deduced that firm size and the barriers faced by SMEs when engaging in IP mechanisms, such as patenting activities, determine the frequency of patenting activities. Finally, research from Ernst (2001) indicates a positive relationship between patent activities and firm performance.

Hypothesis 2a: Intellectual property protection through patents is positively related to firm performance in SMEs.

Hypothesis 2b: Intellectual property protection through patents moderates the relationship between open innovation and firm performance so that the relationship is stronger when patent use is high rather than low.

Industrial designs as well as **trademarks** are considered to be important for taking new products to the market (Kalanje, 2006). In a study by Kitching and Blackburn (1998) the adoption of such industrial designs is at about 31% for SMEs, and about 17% for micro companies in the UK. These rates closely resemble the application of patents, with

around 30% and 18% respectively. An industrial design is a commonly used IP right, especially for SMEs. On average and weighted by employment, Jensen and Webster (2006) found that the intensity of the usage of industrial designs is double the amount for SMEs compared to large firms (0.339 compared to 0.162 design applications per 1.000 employees). Surprisingly, SMEs only use industrial designs in general to a limited extent, even though such design rights are considered to be ideal for SMEs (Burrone, 2005). Earlier research indicates that industrial designs are in general a less chosen IPR that other forms of protection (Hanel, 2006).

> *Hypothesis 3a: Intellectual property protection through industrial designs is positively related to firm performance in SMEs.*
>
> *Hypothesis 3b: Intellectual property protection through industrial designs moderates the relationship between open innovation and firm performance so that the relationship is stronger when industrial design use is high rather than low.*

Eppinger and Vladova (2013) suggest further research into trademarks. However, research on the relationship between trademarks and firm performance is still scarce, even though trademarks can be used as a proxy for innovation (Agostini, Filippini and Nosella, 2016). Trademarks are a relatively cheap and easy accessible IP, and are comparable to patents in regards to availability and quantity of data, while offering an exclusive right for the identification of goods and rights at the same time. However, these rights only persist if the registered trademark is also used (Mendonca, Pereira and Godinho, 2004). Another strong argument for the usage of trademarks is the fact that they generate one of the highest IPR revenues; only the value for patents is higher (Doern, 1999). Agostini, Filippini and Nosella (2016) report that small companies with at least one trademark in their fashion industry sample show higher performance in terms of sales growth than other SMEs with no trademark. However, they cannot find this effect for their other sample in the mechanical industry, where neither trademarks nor patents show a direct impact. A study by Kitching and Blackburn (1998) shows a high adoption of trademarks by SMEs with about 52% of the sample, compared to only about 29% by micro enterprises with less than 10 employees. Research indicates that

innovative performance is linked to trademark analysis (Mendonca, Pereira and Godinho, 2004), and that trademarks can also be used as an indicator for innovation (Schmoch, 2003). Since trademarks are much cheaper, compared to other IPR options, it is likely that more SMEs will turn to trademarks rather than patents (Mendonca, Pereira and Godinho, 2004). Finally, in some analyses, SMEs account for the majority of overall trademark applications (Millot, 2011). However, trademarks have mainly only been investigated in the context of large firms, and less in the context of SMEs, even though the potential for trademark applications by SMEs seems to be high (Agostini, Filippini and Nosella, 2016).

> *Hypothesis 4a: Intellectual property protection through trademarks is positively related to firm performance in SMEs.*
>
> *Hypothesis 4b: Intellectual property protection through trademarks moderates the relationship between open innovation and firm performance so that the relationship is stronger when trademarks use is high rather than low.*

The use of **copyrights** as a tool for saving creative work is gaining momentum, as the rise of ICT in recent years has led to a permanent increasing relevance of such protection (Burrone, 2005). Thomä and Bizer (2013) classify protection mechanism of SMEs into four clusters: an informal protection group, a patent-oriented group, a copyright-oriented group, and a non-protection group. Their empirical study shows that the latter is the most commonly applied by SMEs at 64%, followed by the informal group at 19%, the patent group at 11%, and the copyright group at 6%. Members of the patent-oriented group are considered more innovative, especially in terms of cooperative innovation and new product introductions in the market. In terms of copyrights, they state that the use is widespread across all industry sectors. Finally, the authors highlight that the copyright-oriented group also focuses on trademarks and industrial designs as protection mechanisms. Hence, it can be assumed that the use of copyrights in SMEs is also linked to a higher use of related IPR such as industrial designs. SMEs tend to prefer non-registrable rights, such as copyrights, which are used in a UK sample by more than 50% of all companies (Kitching and Blackburn, 1998). Moreover, Seo, Chung, Chun and Woo (2015) highlight that informal types of value capturing like copyrights can be

especially efficient in the invention stage of product development. Finally, Agostini, Nosella and Soranzo (2015) indicate that informal protection (like trade secrets) might lead to a superior performance.

Hypothesis 5a: Intellectual property protection through copyrights is positively related to firm performance in SMEs.

Hypothesis 5b: Intellectual property protection through copyrights moderates the relationship between open innovation and firm performance so that the relationship is stronger when copyright use is high rather than low.

Methods

Sample and data source

Data from the PITEC database is used, which is the Spanish Community Innovation Survey (CIS), and data for the years 2008 – 2013 is included. The PITEC database is a panel data survey of manufacturing and service firms which engage in innovative activity. Whereas the CIS is carried out biannually, the PITEC is an annual survey. The PITEC is of mandatory character, which results in a very high response rate of over 96 per cent for each of the included years. Firms that were created in the years of the survey, experienced a recent merger or closure, or lack data for some of the years or variables are excluded.

The sample is classified into small, medium-sized, and large firms as per the SME definition of the EU (European Union, 2015): Small firms employ less than 50 people and the annual turnover does not exceed ten million EUR. Medium-sized firms have less than 250 employees and a turnover of 50 million EUR or less. Large firms have 250 employees or more and a turnover of over 50 million EUR. Micro enterprises with less than 10 employees are excluded. When referring to SMEs, both small and medium-sized enterprises are included. The final sample is a balanced panel dataset covering 2,873 firms during six years, i.e. 17,238 firm years.

The firms are also classified according to their industry corresponding to the Eurostat classification which divides industries into low-tech manufacturing (LTM), medium-low-tech manufacturing (MLTM), medium-high-tech manufacturing (MHTM), high-tech manufacturing (HTM), non-knowledge-intensive services (NKIS), and knowledge-intensive services (KIS). The correspondence between PITEC industries and the Eurostat classification is carried out according to the conversion table of Goya, Vayá, and Suriñach (2012).

Earlier versions of the PITEC database have been used to investigate e.g. the complementarity of research and development (Barge-Gil and López, 2013), R&D employment composition (Afcha and García-Quevedo, 2016), the adoption of open innovation (Sandulli, Fernandez-Menendez, Rodriguez-Duarte, and Lopez-Sanchez, 2012), cooperation in service innovation (Trigo and Vence, 2012), human resource barriers to innovation (D'Este, Rentocchini, and Vega-Jurado, 2014), and the impact of firm age on innovation (Coad, Segarra, and Teruel, 2016). Andries and Faems (2013) advocate undertaking research of patenting activities and firm performance with recent data, specifically mentioning data from 2008 onwards. This suggestion is addressed by using data from 2008-2013.

Measures

The dependent variable, *firm performance*, is measured as the turnover for each firm and year. Padilla-Melendez and Del Aguila-Obra (2012) found that market results of R&D projects are the best measure of the success of knowledge transfer and exchange. The time lag effects of the independent variables may vary across firm sizes and also across industries. Therefore the analysis is first conducted without a time lag and then a one-year time lag is introduced. With the time lag, firm performance is thus measured one year after the independent variables for 2009 to 2013. Therefore, one year of observations in the analysis is lost. The natural logarithm of turnover is used to obtain a normally distributed variable while maintaining other variable characteristics.

Open innovation is measured binarily for each firm year as whether the firm engaged in cooperative innovation activity. The survey question for the year 2013 was:

"During the three years 2011 to 2013, did your enterprise co-operate on any of your innovation activities with other enterprises or institutions? Innovation co-operation is active participation with other enterprises or institutions on innovation activities. Both partners do not need to commercially benefit. Exclude pure contracting out of work with no active co-operation." The wording of the CIS is used, which the PITEC survey participants receive translated into Spanish. In line with the definition of open innovation as "a distributed innovation process based on purposively managed knowledge flows across organizational boundaries" (Chesbrough and Bogers, 2014), cooperation is necessary for a distributed innovation process and is purposively managed. The operationalization of open innovation follows that of Sandulli and his colleagues (2012) using the PITEC database.

The use of IP strategies are also measured binarily for each firm year. For *patents*, the survey question for the year 2013 was "During the three years 2011-2013, did your enterprise apply for any patent to protect its technological inventions or innovations?".

For *industrial designs*, respondents were asked "During the three years 2011-2013, did your enterprise register any industrial design or model?". For *trademarks*, the question was "During the three years 2011-2013, did your enterprise register any trademarks?".

For *copyright*, the question was phrased "During the three years 2011-2013, did your enterprise claim copyright?". Whereas the CIS question asks about the efficiency of IP strategies for increasing firm competitiveness, the PITEC asks which strategies the firm had used.

Following previous authors studying open innovation, several common variables are controlled for (Spithoven et al., 2013; Fosfuri, 2006; Leiponen and Helfat, 2010). The variable *turnover from innovation* is used to control for the percentage of turnover that is generated from products introduced during the three years 2011 to 2013 that were new to the market of the firm. *R&D intensity* is also controlled for, calculated as annual R&D expenditure over turnover. Firms with high R&D intensity tend to be more open and innovative (Cassiman and Veugelers, 2006). Internationalization is measured binarily, and a firm is considered international when it caters to international markets.

Statistical method

The hypothesized effects are estimated with a series of random-effects regression analyses. The random-effects models specify the error structure for each firm and therefore controls for heterogeneity between firms, i.e. variables that are different between firms, but that are stable for each firm. This method thus controls for factors such as industry, location, regulatory framework, and belonging to a group, which tend to be consistent over time for each enterprise. Hence time-variant and cross-sectional endogeneity issues (Baltagi, 2008) are avoided. Random effects are preferable to fixed effects as the sample includes a subset of all existing firms. The random-effects model can be expressed as:

$$y_{it} = \alpha + \beta X_{it} + u_i + \varepsilon_{it}$$

where X_{it} is a vector of the independent and control variables, u_i is a random effect for the ith firm, and ε_{it} is the within-firm error (Greene, 1993).

Since the classification according to industry and size tend to be stable within an enterprise, these variables cannot be included while at the same time controlling for firm-specific effects. Therefore separate random-effects regressions is run for each size category and for each industry category.

Results

Table 5 summarizes the hypotheses and the corresponding empirical support as detailed below. The descriptive statistics and correlations among the variables are presented in table 6 for the whole sample. Table 7 reports these descriptive statistics and correlations for the subset of SMEs. Out of the 17,238 firm years in the sample, 11,823 i.e. 69 per cent belong to SMEs. Of the SMEs, 33 per cent used some form of IP strategy. Thus 67 per cent of SMEs did not use any IP strategy, compared to 66 per cent in the sample as a whole. According to the variable means, the most frequently used IP strategy was trademarks, which was employed by 23 per cent of all firms in the

sample and 22 per cent of SMEs. Patents were used by 17 per cent of all firms and 16 per cent of the SMEs, whereas industrial designs where used by 10 per cent of all firms as well as of SMEs. The least used strategy was copyrights, used by only two per cent of both the sample as a whole and of SMEs. Relatively few firms used several strategies simultaneously, the most frequent case being the simultaneous use of patenting and trademarks, which was implemented by seven per cent of the SMEs.

Table 5. Summary of hypotheses and corresponding findings

Hypothesis	Support
Hypothesis 1: Open innovation is positively related to firm performance in SMEs.	Not supported
Hypothesis 2a: Intellectual property protection through patents is positively related to firm performance in SMEs.	Not supported
Hypothesis 2b: Intellectual property protection through patents moderates the relationship between open innovation and firm performance such that the relationship is stronger when patent use is high rather than low.	Rejected
Hypothesis 3a: Intellectual property protection through industrial designs is positively related to firm performance in SMEs.	Supported
Hypothesis 3b: Intellectual property protection through industrial designs moderates the relationship between open innovation and firm performance such that the relationship is stronger when industrial design use is high rather than low.	Not supported
Hypothesis 4a: Intellectual property protection through trademarks is positively	Supported for small firms, rejected for

related to firm performance in SMEs.	medium-sized firms
Hypothesis 4b: Intellectual property protection through trademarks moderates the relationship between open innovation and firm performance such that the relationship is stronger when trademark use is high rather than low.	Supported for medium-sized firms, rejected for small firms.
Hypothesis 5a: Intellectual property protection through copyrights is positively related to firm performance in SMEs.	Not supported
Hypothesis 5b: Intellectual property protection through copyrights moderates the relationship between open innovation and firm performance such that the relationship is stronger when copyright use is high rather than low.	Supported

Table 6. Descriptive statistics and correlations for all firms

	Mean	S.D.	1	2	3	4	5	6	7	8
1. Firm performance	16.531	1.834								
2. Open innovation	0.446	0.497	0.130**							
3. Patents	0.171	0.376	0.064**	0.145**						
4. Industrial designs	0.097	0.296	0.070**	0.036**	0.286**					
5. Trademarks	0.225	0.418	0.054**	0.095**	0.249**	0.338**				
6. Copyright	0.021	0.144	0.014*	0.032**	0.115**	0.188**	0.166**			
7. Turnover from innovation	0.125	0.241	-0.069**	0.083**	0.087**	0.070**	0.071**	0.060**		
8. R&D intensity	0.205	2.123	-0.169**	0.030**	0.045**	-0.014*	-0.000	0.005	0.064**	
9. Internationalization	0.805	0.396	0.140**	0.043**	0.120**	0.084**	0.058**	0.013*	0.028**	-0.053

n = 17,238

** Correlations significant on the 5% level

* Correlations significant on the 10% level

Table 7. Descriptive statistics and correlations for SMEs

	Mean	S.D.	1	2	3	4	5	6	7	8
1. Firm performance	15.600	1.196								
2. Open innovation	0.408	0.492	0.036**							
3. Patents	0.162	0.369	0.067**	0.131**						
4. Industrial designs	0.095	0.293	0.112**	0.009	0.293**					
5. Trademarks	0.220	0.414	0.056**	0.081**	0.241**	0.318**				
6. Copyright	0.020	0.140	-0.010	0.022**	0.100**	0.154**	0.138**			
7. Turnover from innovation	0.134	0.249	-0.075**	0.092**	0.104**	0.080**	0.086**	0.067**		
8. R&D intensity	0.280	2.558	-0.235**	0.041**	0.053**	-0.018*	-0.001	0.005	0.069**	
9. Internationalization	0.808	0.394	0.286**	0.028**	0.099**	0.089**	0.070**	0.005	0.010	-0.067**

n = 11,823

** Correlations significant on the 5% level

There are some high correlations between independent variables, which can be expected since there are several measures for IP strategies. However, the variance inflation factors (VIFs) are under 1.25 and the tolerance over 0.80, which indicates that there are no multicollinearity issues (Kutner, Nachtsheim, and Neter, 2004). For the SMEs, correlations are weaker than for the sample as a whole, particularly between copyright and firm performance, and between industrial designs and open innovation.

Table 8 reports the results of the panel regressions per firm size. Models 1 and 2 include all firms in the sample. In models 3 and 4 the sample is restricted to only SMEs. Models 5 and 6 are similarly restricted to small firms, models 7 and 8 include only medium-sized firms, and models 9 and 10 treat large firms only. Models 1, 3, 5, 7, and 9 do not include the moderating effects, which are included in models 2, 4, 6, 8 and 10.

Table 9 describes the regression results per industry class for the SMEs in the sample. Model 11 includes firms engaged in low-tech manufacturing (LTM), model 12 medium-low-tech manufacturing (MLTM), model 13 medium-high-tech manufacturing (MHTM), model 14 high-tech manufacturing (HTM), model 15 non-knowledge-intensive services (NKIS), and model 16 knowledge-intensive services (KIS).

Model 2 shows that open innovation is positively related to firm performance for firms in general. For the whole sample with firms of different sizes, IP protection through patents and industrial designs is positively related to firm performance. IP protection through trademarks and copyright on the other hand moderates the relationship between open innovation and firm performance so that the relationship is stronger when trademark use is high rather than low. Figure 7 depicts the interaction between open innovation and copyright for the whole sample.

Model 4 reports the results for SMEs and does not support hypothesis 1, which claims that open innovation is positively related to firm performance in these companies. There is no support for this hypothesis in SMEs, small firms (model 6), or medium-sized firms (model 8). The effect for large firms is stronger (model 10) and is behind the positive effect for the sample as a whole.

The results do not support hypothesis 2a that IP protection through patents is positively related to firm performance in SMEs, nor do they support hypothesis 2b about the moderating effect of patents on the relationship between open innovation and firm performance (models 4, 6, and 8). Whereas patenting has both a direct and a moderating effect in the case of large firms (model 10), no impact is found for SMEs.

Model 4 renders support for hypothesis 3a, regarding the impact of IP protection through industrial designs in SMEs. In particular, this relationship is supported for medium-sized firms (model 8), but not for small (model 6) or for large firms (model 10). The support is stronger for SMEs in medium-high and medium-low-technology manufacturing industries than for firms in general (Models 12 and 13). Hypothesis 3b about the moderating effects of industrial designs in SMEs is however not supported.

Hypothesis 4a about IP protection through trademarks is only supported for small firms (model 6), but not for medium-sized (model 8) or large (model 10). The moderating effect of trademarks on the relationship between open innovation and firm performance is not supported for SMEs (model 4) but is supported for medium-sized (model 8) and large firms (model 10). The results of model 15 indicate that the direct relationship between IP protection through trademarks and firm performance is stronger for SMEs in non-knowledge intensive service industries than for firms in general.

Hypothesis 5a regarding the positive impact of copyrights on firm performance is not supported by the results. On the other hand, copyright use does have a positive moderating effect on the relationship between open innovation and firm performance in SMEs as per hypothesis 5b (model 4). This impact does however not hold for medium-sized or large firms when taken separately (models 8 and 10). For high-technology manufacturing SMEs, the impact of open innovation on firm performance is negative when moderated by IP protection through copyright (model 14). The constant and the Wald χ^2 are significant of all models in tables 8 and 9 which asserts the validity of the models. Whereas the Wald χ^2 are highest for SMEs (models 3 and 4), the R^2 is highest for small firms (models 5 and 6), which indicates that the models are particularly suitable

for small firms. However the model does not fit large firms as well, as seen by the lower R^2 of models 9 and 10.

In tables 10 and 11 the regressions with a one-year time lag between independent and dependent variables are run, thus capturing the slower effects of open innovation and IPR on firm performance. There is however a loss one of the six years of data for each firm, which reduces the fit of the model, particularly within firms, as shown for example by the R^2 within firms of model 4 which is reduced from 0.088 in table 8 without the time lag to 0.010 in table 10, where the time lag has been added. The Wald χ^2 is greatly reduced for all models and is not significant for models 12 and 13 in table 11. This loss of data points reduces the support for hypotheses 1, 3a, and 4b. However, table 10 also shows a negatively moderating impact of IP protection through patenting, which was not discernable in the short term. This impact rejects hypothesis 2b and is particularly important for medium-sized enterprises (table 10, model 8) and for firms in high-tech manufacturing (table 11, model 14). The relationship is graphed in figure 8, and it can be observed that the medium-sized firms that patent experience a negative impact on firm performance from open innovation.

The longer-term direct effect of trademarks is also negative for medium-sized firms (table 10, model 8) whereas it remains positive for small firms (table 10, model 6). The moderating effects are however inverse: positive for medium-sized firms, and negative for small firms. For large firms a long-term effect of copyright use is discerned, with a negative direct effect on firm performance and a significant moderating effect.

Table 8. Regression results per firm size

	All		SME		Small		Medium		Large	
Model	1	2	3	4	5	6	7	8	9	10
Open innovation	0.031**	0.024**	0.016*	0.010	0.011	0.011	0.006	-0.006	0.060**	0.050**
Patents	0.017	0.029*	0.004	0.010	0.014	0.016	-0.012	0.001	0.040*	0.075**
Industrial designs	0.033**	0.050**	0.062**	0.062**	0.037	0.039	0.083**	0.080**	-0.018	0.040
Trademarks	0.029**	0.001	0.026**	0.013	0.045**	0.049**	0.005	-0.025	0.053**	-0.018
Copyright	0.018	-0.041	0.020	-0.028	0.003	-0.048	0.016	-0.016	0.007	-0.066
OI × Patents		-0.024		-0.011		-0.002		-0.025		-0.058**
OI × Industrial designs		-0.035		0.001		-0.007		0.013		-0.089**
OI × Trademarks		0.057**		0.027		-0.009		0.062**		0.119**
OI × Copyright		0.113**		0.109**		0.135*		0.057		0.112
Turnover from innovation	0.042**	0.044**	0.023	0.024	0.018	0.018	0.021	0.022	0.093**	0.093**
R&D intensity	-0.049**	-0.049**	-0.049**	-0.049**	-0.047**	-0.047**	-0.060**	-0.060**	-0.660**	-0.664**
Internationalization	0.026*	0.026*	0.056**	0.055**	0.114**	0.114**	0.012	0.011	0.028	0.026
Constant	16.488**	16.491**	15.510**	15.513**	14.617**	14.617**	16.432**	16.437**	18.390**	18.397**
Model diagnostics										
R^2 within firms	0.056	0.058	0.088	0.088	0.100	0.100	0.076	0.078	0.031	0.035
R^2 between firms	0.056	0.055	0.108	0.107	0.221	0.222	0.111	0.108	0.060	0.056
R^2 overall	0.041	0.040	0.084	0.083	0.175	0.176	0.080	0.079	0.051	0.048
Wald χ^2 (df)	899**	923**	1008**	1016**	687**	690**	434**	443**	185**	206**
n	17,238	17,238	11,448	11,448	5,802	5,802	5,646	5,646	5,790	5,790
Firms	2,873	2,873	1,908	1,908	967	967	941	941	965	965

** Estimates significant on the 5% level

* Estimates significant on the 10% level

Table 9. Regression results per industry class for SMEs

	LTM	MLTM	MHTM	HTM	NKIS	KIS
Model	11	12	13	14	15	16
Open innovation	0.001	-0.014	0.033*	-0.066	0.060	0.033
Patents	0.036	0.040	0.017	-0.017	-0.014	-0.022
Industrial designs	0.012	0.073*	0.073**	0.029	0.088	0.101
Trademarks	-0.015	0.053*	-0.016	-0.002	0.105**	0.027
Copyright	-0.017	-0.000	-0.064	0.234	-0.207	-0.003
OI × Patents	0.023	-0.026	-0.005	-0.069	-0.034	0.022
OI × Industrial designs	0.056	0.023	0.007	-0.009	-0.058	-0.042
OI × Trademarks	0.021	0.015	0.039	0.094	-0.091	0.036
OI × Copyright	0.150	0.112	0.172**	-0.725**	0.100	0.107
Turnover from innovation	0.040	0.010	0.003	0.064	0.015	0.049
R&D intensity	-0.434**	-0.052**	-1.301**	-0.058**	-0.325**	-0.047**
Internationalization	0.016	0.091**	0.014	0.107	0.076	0.023
Constant	15.822**	15.832**	15.888**	15.637**	15.403**	14.845**
Model diagnostics						
R^2 within firms	0.028	0.016	0.048	0.132	0.197	0.171
R^2 between firms	0.096	0.078	0.108	0.077	0.152	0.132
R^2 overall	0.061	0.058	0.082	0.072	0.112	0.117
Wald χ^2 (df)	51**	35**	151**	107**	121**	571**
n	1,854	2,034	3096	810	576	3078
Firms	309	339	516	135	96	513

** Estimates significant on the 5% level

* Estimates significant on the 10% level

Table 10. Regression results per firm size with one-year time lag

	All		SME		Small		Medium		Large	
Model	1	2	3	4	5	6	7	8	9	10
Open innovation	0.009	0.007	-0.005	-0.002	-0.024	-0.013	-0.002	-0.007	0.031**	0.024
Patents	0.000	0.012	0.000	0.023	-0.004	0.011	-0.004	0.031	-0.003	-0.011
Industrial designs	0.029**	0.025	0.044**	0.022	0.057**	0.021	0.034**	0.022	0.008	0.057
Trademarks	0.023**	0.016	0.006	0.011	0.029*	0.056**	-0.022	-0.042**	0.065**	0.040*
Copyright	-0.003	-0.038	0.003	-0.007	-0.053	-0.038	0.039	0.002	-0.032	-0.128**
OI × Patents		-0.020		-0.043*		-0.032		-0.064**		0.013
OI × Industrial designs		0.005		0.052*		0.091**		0.027		-0.079*
OI × Trademarks		0.014		-0.009		-0.066**		0.044**		0.042
OI × Copyright		0.069		0.020		-0.052		0.074		0.153**
Turnover from innovation	0.038**	0.038**	0.027	0.027	0.024	0.022	0.020	0.020	0.064**	0.064**
R&D intensity	-0.016**	-0.016**	-0.017**	-0.017**	-0.017**	-0.017**	-0.042**	-0.041**	-0.040	-0.042
Internationalization	0.025**	0.025*	0.064**	0.064**	0.153**	0.0153**	-0.011	-0.010	0.014	0.013
Constant	16.475**	16.476**	15.491**	15.490**	14.575**	14.571**	16.445**	16.446**	18.370**	18.374**
Model diagnostics										
R^2 within firms	0.008	0.008	0.009	0.010	0.010	0.012	0.019	0.022	0.005	0.008
R^2 between firms	0.053	0.052	0.143	0.140	0.265	0.266	0.080	0.079	0.034	0.028
R^2 overall	0.035	0.035	0.099	0.096	0.188	0.189	0.057	0.056	0.024	0.020
Wald χ^2 (df)	107**	112**	124**	130**	138**	146**	100**	109**	29**	38*
n	14,365	14,365	9,540	9,540	4,835	4,835	4,705	4,705	4,825	4,825
Firms	2,873	2,873	1,908	1,908	967	967	941	941	965	965

** Estimates significant on the 5% level

* Estimates significant on the 10% level

Table 11. Regression results per industry class for SMEs with one-year time lag

	LTM	MLTM	MHTM	HTM	NKIS	KIS
Model	11	12	13	14	15	16
Open innovation	0.007	-0.028	0.029	-0.132**	0.075	0.008
Patents	0.037	0.006	0.064**	0.091	-0.059	-0.029
Industrial designs	-0.032	-0.027	0.056**	-0.071	0.066	0.040
Trademarks	-0.028	0.059**	0.000	-0.059	-0.040	0.054
Copyright	0.019	0.083	-0.033	-0.180	-0.058	-0.003
OI × Patents	-0.002	0.008	-0.067**	-0.212**	-0.077	0.004
OI × Industrial designs	0.102**	0.081	-0.005	0.158	0.001	0.034
OI × Trademarks	0.015	-0.045	-0.006	0.151**	-0.072	-0.042
OI × Copyright	-0.103	-0.082	0.073	-0.411	-	0.072
Turnover from innovation	0.058*	0.048	-0.018	0.147*	-0.044	0.024
R&D intensity	-0.256**	0.018	-0.028	-0.033**	-0.125**	-0.016**
Internationalization	0.015	0.089**	0.040	0.196*	0.099	0.022
Constant	15.803**	15.814**	15.786**	15.544**	15.382**	14.820**
Model diagnostics						
R^2 within firms	0.018	0.008	0.006	0.072	0.041	0.019
R^2 between firms	0.065	0.046	0.044	0.026	0.128	0.129
R^2 overall	0.040	0.033	0.030	0.027	0.094	0.084
Wald χ^2 (df)	26**	15	17	43**	20**	58**
n	1,545	1,695	2,580	675	480	2565
Firms	309	339	516	135	96	513

** Estimates significant on the 5% level*

Estimates significant on the 10% level

Figure 7. Interaction between open innovation and copyright for the whole sample

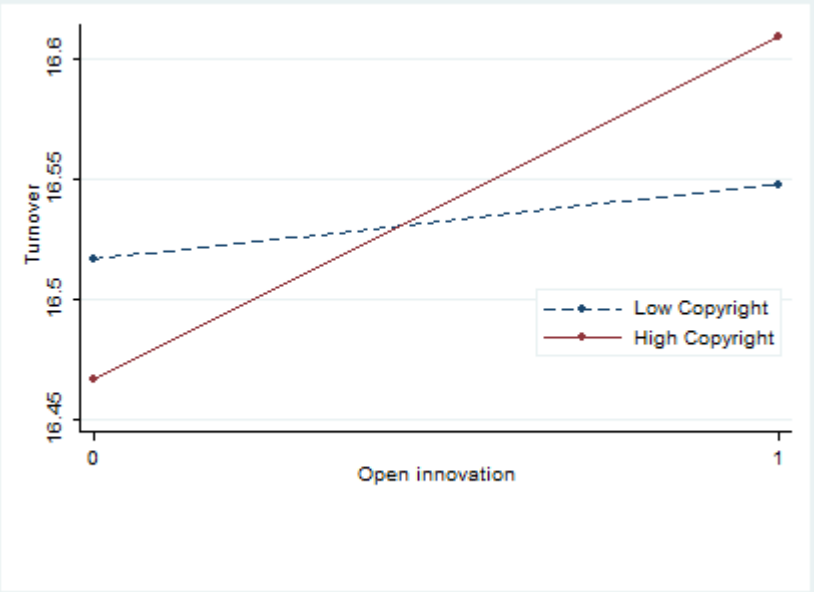
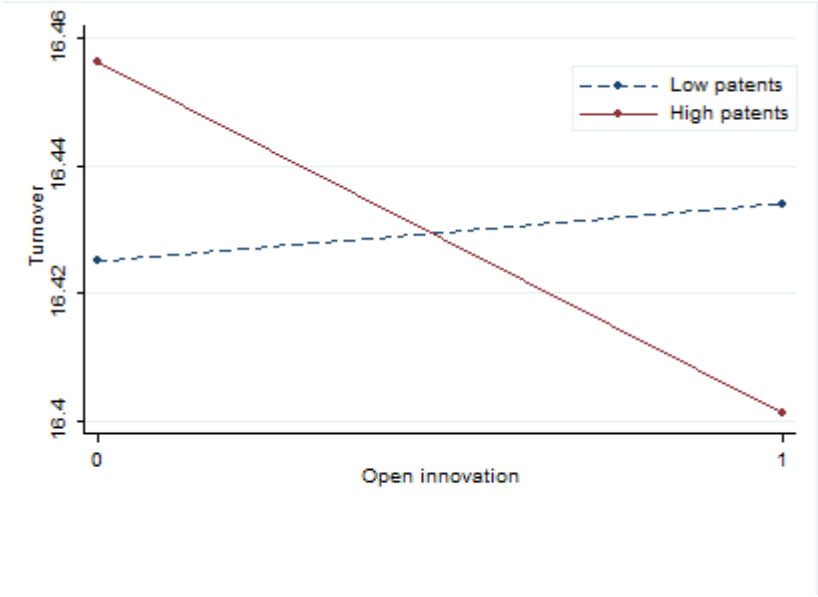


Figure 8. Interaction between open innovation and patents with time lag for medium-sized firms



Discussion and Theoretical Implications

Comparably little is still known about the linkage of a companies' attitude to appropriability with their open innovation activities (Laursen and Salter, 2014).

The findings show that although open innovation has a positive impact on firm performance in SMEs, this impact occurs only when coupled with suitable IPR strategies and is weaker for SMEs than for large firms. Given the trend towards open innovation in SMEs (van der Vrande et al., 2009), it is worrying that open innovation does not have a clear positive impact on firm performance. As Spanish firms are less propense to collaborate in innovation compared to firms in other EU countries (Guimón and Salazar-Elena, 2015), the importance of coupling open innovation and IPR strategies may be even more important in other settings. The results thus align with those of Lee et al., (2009) and Kim and Park (2010) in claiming that open innovation is not necessarily always positive for SMEs. They also support the findings of Agostini, Filippini and Nosella (2016), who found that small firms profit differently from IPR in terms of firm performance as compared to medium-sized or large companies. Hence, it is highlighted that the generally used term "SME" might be too broad to cover such a huge amount of differently sized companies. Future studies need to analyse in more detail each category of the European Union (2015) definition, e.g. with medium-sized firms ranging from 50-250 employees and 10 to 50 million EUR of sales.

On the firm level, the increased costs related to open innovation possibly reduce the resulting profit. This claim is supported by current research. For example, the costs for IP protection may be a culprit: Eppinger and Vladova (2013) point out that SMEs may be unable to afford the expense of certain patenting activities, such as hiring external legal experts, which is also supported by Kalanje (2006) who states that cost and lack of resources hinder SMEs from patenting. Even if they patent, they often use patents only to protect from imitation rather than using it as a basis for their own successful product development (MacDonald, 2004). This is in contrast to big companies which usually have distinct legal departments for IP related issues (Hanel, 2005). When SMEs patent, they focus on innovations where they see a very high probability of market

success, rather than applying systematic patenting to protect specific technology areas (Spithoven et al., 2013). This is why MacDonald (2004) argues that the patent system itself is designed for large companies, and at the same time much less attractive to small and medium-sized firms.

Family-run businesses, of which most are small to medium-sized, make up 89% of all businesses in Spain, and create 67% of private employment (Instituto de la Empresa Familiar, 2016). In such firms, a small number of family members are responsible for decision-making, which is influenced by past experiences and decisions, which in turn can lead to entrenched processes, and finally organizational inertia. Changes in the business environment pose a threat to organizations suffering from inertia, since they are slower at reacting to such changes (Huang et al., 2013). Family members also have a personal interest in the firm, and therefore may make strategic decisions based not on what is best for the organization, but on what is best for family members. Lasagni (2012) states that such behavior may lead to family members making less innovative changes. Additionally, since it is possible that the creator of the firm is also the owner of an SME, a change in mindset, vision and leadership may be needed to bring an innovation to fruition (Harryson, 2008). This is in line with Kirchbaum (2005), who stated that the different stages of innovation have different objectives, and therefore a different management style may be needed at each stage. In essence: success may depend on a change in managerial mindset.

When it comes to the use of IP strategies, the results show a negative impact of patenting on the turnover for medium-sized firms that engage in open innovation. These findings contradict earlier studies suggesting a positive link between patenting and firm performance in SMEs (e.g. Andries and Faems, 2013; Spithoven et al, 2013). However, this might be linked to the fact that SMEs in Europe tend to patent less than larger companies in general. Small firms in particular fear litigation, so they are much less involved in such legal issues than large companies (Hanel, 2006). The arduous patenting process may cancel out any positive effects (Kalanje, 2006), contrary to previous research (Andries and Faems, 2013, Thomä and Bizer, 2013). Although previous research suggests that SMEs file less patents in total, the results show the proportion of SMEs that engage in patenting and other IP strategies is nearly as large

as for firms in general (33 per cent vs. 34 per cent), although each SME may file fewer patents. SMEs only patent a little less than firms in general, whereas the lack of impact on firm performance may call for less patenting. This is in line with Thomä and Bizer's (2013) argumentation, that efficiency of a patent is simply too low if the amount which needs to be spent to obtain the patent is too high.

As stated by Burrone (2005), SMEs tend to focus on patents rather than on alternative options. In contrast, the results show that 17 per cent of SMEs use patents, with 22 per cent of SMEs relying on trademarks. This result does not align with earlier research on IPR in SMEs, where it is assumed that SMEs prefer trademarks because of the comparably low costs (Mendonca, Pereira and Godinho, 2004). In terms of IP strategies, only 7 per cent of all SMEs use patents and trademarks simultaneously. This is surprising as technological developments can be saved strategically through such combinations (Kalanaje, 2006).

The usage of industrial designs in this sample is comparably low with 10% of all company sizes, and within the sample of SMEs, compared to a study in the UK with over 30% (Kitching and Blackburn, 1998). However, other research indicates that such rights are generally less used by SMEs (Hanel, 2006; Burrone, 2005) and that small firms tend to avoid using registered IPR (Thomä and Bizer, 2013). Medium-sized firms could opt for industrial designs, especially if they are active in medium-high and medium-low-technology manufacturing industries. This IP strategy does not, however, improve the firm performance of small firms, based on the results. An explanation for the low number might be the fact that companies prefer to opt for an examined patent, rather then rely on an unexamined industrial design. Another reason might the fact that these companies focus more on technological development and the positioning of a brand in the market, than protecting a distinctive design appearance.

Trademarks are the most used IP right in the sample, which is in line with other studies, such as Kitching and Blackburn (1998). This is not surprising as such rights are comparably cheap and easy to access, while offering specific protection to a product (Mendonca, Pereira and Godhinho, 2004). This is also shown by earlier research which highlights that trademarks typically generate a very high IPR revenue (Doern, 1999),

and that SMEs with innovations of a mainly informal nature rely more on trademarks and related IPR to differentiate themselves (Burrone, 2005). This empirical investigation has however shown that the impact on firm performance of using trademarks in combination with open innovation is complex, and that short-term positive effects may be reduced by negative effects in a longer term.

Copyrights protect literary, artistic and scientific work (Bogers, Bekkers and Grandstrand, 2012), which is especially important in areas like software development. Companies in the sample do not use copyrights strategically, with a share of only 2%. Despite a rise in importance in recent years through ICT, it might be the case that a high percentage of SMEs does not know that they can also use copyrights strategically as an IP right. One explanation could be the fact that copyrights are granted through publication, without further formal processes. According to the findings, relying on copyrights for IP protection does not help firm performance.

Managerial and policy implications

The results not only have major implications for managers in these companies, but also for policymakers, in order to foster innovation in all kind of SMEs, which are so important for regional economies.

The inefficient use of open innovation may be hindering SMEs from reaping the benefits of openness. As with most processes, open innovation is likely to become more efficient as firms gain experience, which would explain why large firms are benefiting more from openness. Both managers and policy makers may thus want to engage in initiatives that accelerate the experience curve for open innovation in SMEs. As Spanish firms engage relatively little in open innovation (Guimón and Salazar-Elena, 2015), firms in some other countries may be at a more advanced stage in this experience curve. Both regions and firms could consider their previous experience with collaborating in innovative activities in order to become more efficient. Companies may want to start taking small steps towards engaging in open innovation, to gain experience and to find out if and how they might benefit from such collaborations. As the field of open innovation is maturing, courses and other learning materials are becoming available for managers to learn how to engage efficiently in open

innovation. Since this research underlines the importance of efficient open innovation and a correct coupling of open innovation and IPR, managers are encouraged to seek training in this respect.

While it would not be wise to go so far as to say SMEs should not patent, they may be well advised to employ other forms of IP protection if they cannot patent efficiently. Similarly, the long-term negative effects of using trademarks call for caution when using this form of protection. A more targeted use of copyrights may be useful because of the low costs and ease of formal application, these options can also be applied by small companies. However, the low enforcement of such rights should be taken into consideration, and that also competitors might abreast of the new development.

For policy makers, supporting more efficient patenting and trademark processes in SMEs would be a way to improve the efficiency of innovation in general, and of open innovation in particular. In many countries such initiatives are already in place, so company leaders should carefully take such options of support into consideration.

Finally, it is worth mentioning external collaborations like open innovation activities need to be embedded in an overall strategy for acquiring external knowledge. For this reason, research suggests using decision support frameworks as proposed by Howells, James and Malik (2004).

Limitations and further research

To the best of my knowledge, this study is the first to focus on all available IPR, namely patents, industrial designs, trademarks and copyrights, in relationship with open innovation and firm performance in an SME context. Beyond this newness there are also some important limitations to face.

A main limitation of this chapter is that the appropriability paradox of IP protection is not taken into consideration, which is highlighted in earlier research as a critical factor (Laursen and Salter, 2014). I acknowledge that it is important to consider legal and strategic aspects of appropriability regimes. As mentioned earlier, other publications that address this issue in depth are referred to, which may be necessary to cover this paradox in its full scope. Regarding this issue, I analyse only the IPR activity itself, and

not its impact. For instance, a company may have very few IPR, but it may have set an industry standard with these rights, called dominant designs (Brem, Nylund and Schuster, 2016). Such research might also be a potential track for new projects.

A further limitation of this study is the focus on Spain, even though there are several good reasons why this analysis regarding companies of this country makes sense (e.g. EASME, 2016). However, since markets and policies within the European Union are diverse, the results cannot easily be transferred to other countries and regions. This offers a starting point for future research, which should follow this analysis in other countries, especially in the EU.

A key limitation of this chapter is the fact that businesses mostly rely on a protection form which cannot be measured by IP data, namely secrecy. Hence, future research should also include specific questions to analyse relationships between the use of secrecy and other IP options. Another track for future research is to break the definition of open innovation down to its components: e.g. collaboration could be to gain knowledge (outside-in) or to export knowledge (inside-out).

Another limitation is measuring IP with four binary variables, a choice linked to the focus on contrasting the four types of IP use. The focus on contrasting the four types of IP use limits the depth in which I investigate each construct. The degree of use of each type, e.g. the number of patents, as well as the reasons for choosing a certain type of IP when engaging in open innovation would be fruitful avenues of further study.

Moreover, IP is also related to high transaction costs (Bogers, Bekkers and Granstrand, 2012). Future research should take this further into consideration. Another key aspect is the usage of the term SME. Given that the results indicate rather diverse results depending on the category according to the European Union (2015) definition, I recommend undertaking more studies which focus on each subcategory to analyze effects for each industry class. In addition, this study did not distinguish between the different sub-types of open innovation, like coupled processes. As these processes are supposed to have an impact on protecting collaborative innovation activities, future studies should consider them (Bogers, Bekkers and Grandstrand, 2012). Another

avenue for research could be the area of competitive intelligence: if and how do SMEs use e.g. patent documents as sources of innovations? (Kalanje, 2006).

Furthermore, it is difficult to quantify and decide what exactly constitutes open innovation. While idea competitions, collaborations, cooperation with suppliers and competitors, spin offs, and licensing agreements are examples of formal open innovation, the question remains: how to define and quantify informal open innovation? Does a 5-minute meeting in a bar that has a beneficial outcome (in terms of innovation) count as open innovation? What if the outcome is not beneficial? Does it still count as open innovation? It is for this reason that we chose the variable *"During the three years 2011 to 2013, did your enterprise co-operate on any of your innovation activities with other enterprises or institutions? Innovation co-operation is active participation with other enterprises or institutions on innovation activities. Both partners do not need to commercially benefit. Exclude pure contracting out of work with no active co-operation."* While this variable enables us to quantify the effect of cooperation, or open innovation, it does not make clear what cooperation isn't. For those respondents who reported not cooperating with other enterprises or institutions, perhaps they have a different vision of what cooperation is, which is in itself an abstract concept. Open innovation is still in its infancy, and since there is no minimum definition of what open innovation is, and isn't, future research could seek to explore this question.

In chapter 2 I find that there is no one, best way to measure the outcomes of open innovation in SMEs, thereby identifying a research gap. I then attempt to measure IPR in relation with firm performance and open innovation in SMEs by using data on IRP strategies, since this data *can* be found in the PITEC database. Since the Open Innovation Paradigm presumes "a bountiful supply of potentially useful new ideas outside the firm and that the firm should be an active buyer and seller of IP" (Chesbrough, 2003), it stands that although measuring the impact of open innovation in SMEs using data on IPR is a purely exploratory path, it is perhaps one of the only ways of doing so using quantifiable data which is readily available.

In a world where knowledge is dynamic, IP can be used to "create and extend markets for their technology" (Chesbrough, 2003). This is in line with the view that governments, or Entrepreneurial States, can imagine a new direction technological change, and create new markets (Mazzucato, 2015).

According to (West & Gallagher, (2006), open innovation is more than exploiting external sources: it is about a change in "the use, management, and employment of IP as it is in the technical and research driven generation of IP".

Perhaps it would be timely to clarify that although open innovation and open source software (OSS) share similarities, while OSS is a kind of open innovation, open innovation goes beyond OSS. Shared rights in the technology which arises from collaboration and the element of collaborating used *donated* labour are both good examples of OSS (West & Gallagher, 2006). OSS may be a useful tool for working on a specific problem, but open innovation relies on a network of sources in order to creatively exploit a firm's IP: customer, rivals and even firms operating in different industries. Open innovation emphasises scanning for external knowledge for financial gain and to maximise returns from IP. On the other hand, OSS code can be modified and redistributed by programmers who were originally hobbyists, and who now include paid professionals. Participants are motivated to work on OSS because of three principal reasons: it is useful to them directly; they learn a skill or attain some kind of personal satisfaction; and they can demonstrate their skills (West & Gallagher, 2006). Therefore, open innovation is about financial gain, whereas OSS isn't necessarily: it can also be related to more intrinsic, altruistic motives. The overlap between open innovation and OSS lends more weight to the fact that knowing exactly what constitutes open innovation is still a complex, which I have mentioned previously in this chapter.

An interesting direction that has not been contemplated in this study is the relationship between family-run SMEs and open innovation, focusing on IP activities. Future studies could analyse the management behaviour of IP practices and decision-making processes in family-run SMEs, and compare it to other SMEs or large firms. I

also encourage future research with other industry samples, including different countries in Europe, Asia and the US.

A further question which could be explored is that of what happens when patents expire. In the context of the pharmaceutical industry, the Drug Price Competition and Patent Term Restoration Act of 1984 intended to lower the entry barriers for generic drug manufacturers, which consisted in no longer requiring generic manufacturers to duplicate the results of safety tests, originally carried out by the pharmaceuticals with the patents. The results of these tests were not readily available for generic manufacturers, therefore posing a significant barrier to entry. The US government encouraged the use of generic drugs; repealed laws which prohibited chemists from deviating from brand-name prescriptions; health insurers pursued lower-price alternatives; and customers became more price conscious. While lowering prices for consumers and lowering entry barriers for generic manufacturers, the Act also results in lower market shares and profits for innovating companies after their patents expire, with a knock-on effect on returns from R&D and therefore less drug innovation. While the 1984 Act also granted patent extensions of up to 5 years, it is linked to a moderate negative effect on investment in R&D in some cases, and a more significant effect on innovative firms which invest heavily in R&D (Grabowski & Vernon, 1986). Therefore, the 1984 Act results in a decrease in prices and an increase in imitation. The pressure on the innovative, patent-holding firm is to commercialise new products in order to offset the R&D costs within the patenting period. Future studies could focus on the mechanisms to achieve this, or strategies adopted by firms when their patents expire. How can firm compete with generic firms, and what part do pricing strategy and marketing play in this?

In conclusion, SMEs do not yet efficiently engage in open innovation. Amongst other initiatives that could help accelerate the path of SMEs towards benefiting from open innovation are more efficient patenting processes. Meanwhile, SMEs are better off relying on IP strategies such as trademarks or industrial designs to protect IP in open innovation.

Chapter 4

Social Media practices for Open Innovation in SMEs

Why social media may revolutionize innovation

Innovation is no longer reserved for companies with gigantic R&D departments and billion dollar research budgets. Organizations are compelled to adopt alternative ways to innovate due to labour mobility, abundant venture capital, and widely dispersed knowledge across multiple public and private organizations (Van de Vrande et al. 2009). Multinationals such as Volkswagen, Samsung, Intel, Microsoft, and Roche still lead the R&D spending league with $10 billion per year each (Jaruzelski, Staack, & Goehle, 2014), but much innovation come from small and medium-sized enterprises (SMEs). SMEs may be more capable than larger firms when it comes to radical innovation, especially in "new-to-the–world innovation", due to their greater flexibility (Lee et al. 2010). Open and collaborative innovation processes reduces the reliance on in-house resources for innovation and open up the venue of innovation to small business and entrepreneurs (Parida, Westerberg, & Frishammar, 2012).

Open innovation is the management of inflows and outflows of knowledge to accelerate innovation and expand the markets for it. The concept of open innovation synthesizes an idea that has been brewing in recent years: Innovation is a complex phenomenon of social nature. We need to use social networks, such as networks of knowledge and trust, to innovate effectively (Chesbrough, 2003). Innovation is therefore increasingly hatched in social and organizational networks (Freeman, 1991). Open innovation builds on earlier conceptualizations of innovation. One fundamental pillar is the perspective of innovation as a systemic phenomenon, i.e. a phenomenon that requires a system of interconnected agents, so that a change in one of them strongly affects the whole (Cooke, Gomez Uranga, & Etxebarria, 1997). Innovation strategies then had become systemic strategies focused on the coevolution of entire systems, including sophisticated demand, specialized suppliers, knowledge providers,

entrepreneurial culture, support infrastructures, etc. (Lewin & Volberda, 1999). Another conceptual basis for open innovation can be found in the interface between disciplines (Griliches, 1992). Crossing ideas and knowledge of different sectors and technologies creates new extremely fertile areas, such as the intersection between food and pharmaceuticals, computing and mobility, or economics and physics. Increasingly, the real transformative projects are consortium projects, often multidisciplinary projects capable of creating unique combinations. Finally, innovation cannot be fragmented but needs to be approached as an integrated process (Armour & Teece, 1980). In this context, most companies need to collaborate to compete. Open innovation has been studied in the context of multinational corporations (Schneckenberg, 2015) and has been embraced by most major global corporations such as Phillips, Xerox, Siemens, and Bayer (Gassmann, Enkel, & Chesbrough, 2010). Start-ups and entrepreneurs have even greater incentives for collaboration since they often work with scarce resources. It is impossible to generate all the necessary knowledge internally. It is impossible to identify all opportunities for the organization. It is unlikely that all ideas generated can be applied onto our traditional market. Some of the key resources for competing will be the possession of strategic intelligence, the ability to swiftly locate key sources of knowledge, and the skill to identify opportunities where they occur. These are the capabilities that compose open innovation.

While much has been written about open innovation in large, multinational enterprises, an area which has yet to be explored fully in academic literature is open innovation in small to medium-sized businesses (Lee et al. 2010). When we consider the impact of SMEs on the economy, the importance of their role in innovation becomes clear. SMEs represent 99% of businesses in the U.S. as well as in the European Union and Japan, and generate employment for two thirds of people employed in the private sector. SMEs are a thus a key driver for economic growth, innovation, employment and social integration (European Commission, 2014). Research suggests that the role of SMEs in open innovation will increase (Zeng, Xie. & Tam, 2010), with a positive trend towards open innovation in SMEs (Van de Vrande et al., 2009).

Open innovation can be accelerated by the use of social media, which is an important tool for improving the inflows and outflows of knowledge in the entire innovation funnel (Mount & Garcia Martinez, 2014). Social media has been defined as Internet-based applications that allow the creation and exchange of user-generated content, e.g. LinkedIn, Facebook, Twitter, Pinterest. (Kaplan & Haenlein, 2010). Together, they constitute an interactive, collaborative online ecosystem (Karakas, 2009). The study of social media for innovation focuses on engaging users in the innovation process (Baldwin & Hippel, 2011; Hardwick, Cruickshank, & Anderson, 2012; Piller & West, 2014; Martini, Massa, & Testa, 2014; Mount & Garcia Martinez, 2014). We move beyond customer co-creation and take a broader approach to SME innovation through social media

Innovation in SMEs

SMEs are particularly susceptible to open innovation since in order to compete and maintain an advantage in the marketplace, SMEs depend on their ability to innovate (Parida, Westerberg, & Frishammar, 2012). Open innovation mitigates some of the obstacles to innovation in SMEs. These obstacles have received significant attention in literature. Firstly, the smallness of the enterprise, and therefore its financial resources, makes it difficult to recruit researchers (Lasagni 2012). Such a lack of resources also has a negative effect on various processes, including manufacturing, distribution, marketing and R&D (Lee et al. 2010). It is also more difficult for SMEs to spread risks associated with innovation, as their size and limited resources mean they can only work on a few innovation projects at the same time (Van der Vrande et al. 2009). Secondly, in family-run SMEs, there may be some conflict between what is best for the business, and the individual objectives of family members, which could affect risk taking when making radical changes, and therefore innovation (Lasagni 2012). In addition, due to their smallness, SMEs also lack a multidisciplinary competence (Bianchi et al. 2010), and tend to use a more informal approach to innovation (De Toni & Nassimbeni, 2003). Finally, collaboration with external partners may pose a barrier to open innovation, due to differing organizational and cultural aspects (Van der

Vrande et al. 2009). Hence, “the way we do things around here”, or the organizational culture of a firm, can be an obstacle to open innovation in SMEs, with differences in traditions, procedures, norms and language as barriers to collaboration with external partners (Christensen et al., 2005). Adaption for exploration and adoption of open innovation is higher in medium-sized enterprises than for small enterprises (Van de Vrande et al. 2009). This points to firm size being a decisive factor in the open innovation process.

Any competitive advantage an SME may have in the market is a result of being able to innovate (Parida, Westerberg, & Frishammar, 2012). SMEs differ to MNEs in open innovation practices in that their inherent smallness is a liability, limiting both human and financial resources (Grando & Belvedere, 2006). Despite increased flexibility in SMEs, financial constraints mean that they unable to complete the innovation process from start to finish, and therefore have to look outside the firm for collaboration. Conversely, this very smallness is also an advantage to the uptake and assimilation of open innovation practices, as SMEs are usually more informal organizations, more inclined to indulge in risk taking, and more specialized. Whereas MNEs have the financial capacity to maintain in-house R&D departments, SMEs can use their smallness to their advantage and respond to changing demands. SMEs are effective at using open innovation to respond to the market: whether focusing on opening new markets or revenues and growth (Van de Vrande et al. 2009). Therefore, smallness does not have to be a barrier to open innovation, and the inherent implications of being an SME, for example, informal structure, risk taking, and specialization, could lead to an increase in R&D.

One such way SMEs can overcome their smallness to compete with MNEs is through collaboration with R&D laboratories and universities (Lasagni, 2012), and with competitors (Van Hemert, Nijkamp, & Masurel, 2012). Collaborations with larger partners are made possible through dual value appropriation, where both partners are able to full appropriate the value created through innovation (Pérez & Cambra-Fierro, 2015).

The open innovation process at Aurea Productiva

To understand how SMEs tackle the open innovation process, I studied the case of start-up Aurea Productiva and the development of its INCO-I tool for operational strategic analysis and benchmarking. Founder Sergi Mussons explained the process Aurea Productiva used to incorporate knowledge from outside the company in their innovation.

Aurea Productiva started out as an operations consulting business. They realized most of their clients had no strategic plan and no strategic alignment within their executive committees, and therefore made investments based on misconceptions of their competitive advantage. The focus of Aurea Productiva therefore shifted towards the definition of competitive advantage and the alignment of operational strategy with this competitive advantage. Understanding that they could only help a limited number of clients in person, Aurea Productiva thought about creating an automated tool that could help more companies to align strategy with competitive advantage. The vision of Aurea Productiva is for companies to create operational strategy based on a perfect understanding of their competitive advantage.

To achieve their vision Aurea Productiva needed to create a benchmarking tool for which companies could measure themselves against other business units and companies. This would require a growing database of benchmarks that companies create when they use the tool. Aurea Productiva got in touch with industry organizations and operations departments of some universities who had experience in similar tools. They identified other benchmarking tools on the market, but existing tools tend to be limited to a specific industry. In some cases, the tool is a simple guide of best practices. In addition, Aurea Productiva wanted a tool that would combine operational strategy with the company's experience in operational excellence. They found there was a gap between their idea and existing tools. This was a gap that could be filled only through innovation.

Aurea Productiva made two important changes in the definition of their innovation during the first eighteen months of the company. The first reconceptualization happened when Aurea Productiva explained their idea to an international consultant with long experience in operational strategy. He introduced Terry Hill's concepts of order qualifiers and order winners (Hill, 2000). An order qualifier is a necessary condition for the offering to be considered by the customer whereas an order winner is a characteristic that wins the bid. The framework was a perfect fit for the INCO-I tool and the classification became a defining feature. The second reconceptualization was the result of a conference on Quick Response Manufacturing that Aurea Productiva organized at a local business school. Aurea Productiva took the chance to introduce their tool to the conference participants and who responded with specific needs from students. Aurea Productiva realized their tool could be used to teach students about operational strategy and went on to create a specific version of the tool for business schools.

During the initial stages of the project, Aurea Productiva was able to build on their experience in operational excellence and collaborations where initiated through incidental meetings and known contacts. An early version of the tool was tested by eighty companies in the contact list of Aurea Productiva. As the definition of the tool proceeded however, knowledge in operational strategy became a limiting factor. This gap between the needed knowledge and the knowledge accessible to Aurea Productiva could possibly be filled by new collaboration partners.

Through the LinkedIn platform for professional contacts, Aurea Productiva contacted operations consultants and university teachers to complement their knowledge and develop the tool. Getting in touch with the most valued experts in the field proved a challenge. LinkedIn can be used to search for experts, but to be perceived as a trustworthy partner requires personal contacts. Aurea Productiva perceived an inflection point in their network creation after participating in a conference on operations strategy in Arnhem in the Netherlands. The company was able to add over fifty international operations managers and consultants to their LinkedIn network and where through these contacts able to connect with the foremost experts in the field. These new knowledge brokers gave the network the necessary premises for open

innovation. The trustworthiness of their LinkedIn network now enables Aurea Productiva to engage with people who possess the required knowledge in operational strategy. However, they hesitate to reach out again to those experts that denied the contact before Aurea Productiva achieved its trustworthy status. Those sources of knowledge may be forever lost for Aurea Productiva and can be considered a cost for learning how to engage in open innovation through social media.

The open innovation ladder

Based on the experience of Aurea Productiva, a framework for open innovation powered by social media is developed, called the Open Innovation Ladder. This innovation framework, depicted in figure 9, is very different from traditional innovation processes as it is explicitly developed for companies to get the most out of open innovation powered by social media.

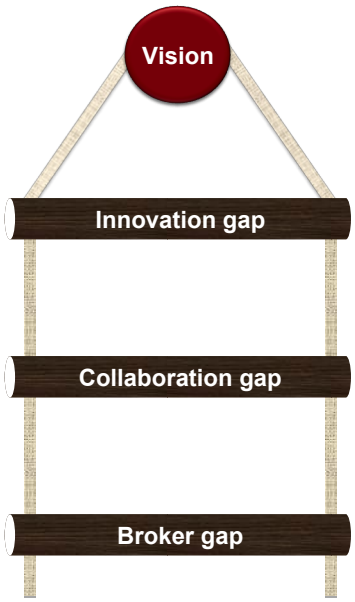


Figure 9. The Open Innovation Ladder

The open innovation ladder is built in four steps; the vision, the innovation gap, the collaboration gap, and the broker gap. The framework constitutes an iterative process,

i.e. managers may have to go back and revise the innovation gap as they begin to close the collaboration gap.

Vision

The open innovation ladder can be visualized as a rope ladder. Unlike other ladders it cannot be supported from below but must be hung from above, pegged on the company vision. Without a distinct vision, the open innovation ladder will collapse into a pile of ideas with no purpose. The vision outlines the future of the innovation and the business. It is the brightest future the company can possibly achieve, and is therefore in itself a product of creativity and innovation (Quinn, 1985). For the vision to focus social interaction and turn it into innovation, the company needs to make its networks part of the vision. Spreading a vision throughout a company is no easy task, and neither is sharing a vision through social media. The keyword, as always when interacting on the Web 2.0, is sharing. Sharing the vision does not consist in imposing a ready-made visualization of the future, but about understanding the vision and motives of partners and knowledge sources and finding out how their visions align with the envisioned future of the company.

Innovation Gap

The next step is to identify what type of innovations are needed to achieve the vision. The company may need e.g. a new way to reach customers, more flexible services, or a breakthrough product. To overcome the challenge of disconnecting innovation and the company resources, it is important to focus on the vision and how the company could get there, without imposing resource limitations just yet.

Collaboration Gap

The next step in the innovation ladder is to consider the resources needed to close the innovation gap and create the innovation necessary for achieving our vision.
Identifying the resources also involves identifying where these resources are located and how they can be accessed. Knowledge can often be accessed by collaborative means, and identifying the required knowledge and the holders of this knowledge is a step towards knowledge access (Chesbrough, 2003).

Broker Gap

Some of the desired connections will be with people we understand and trust, but to fully profit from open innovation, companies want to connect to different knowledge sources that are less known. Managers sometimes need help to sort through the abundant information and identify what is to be trusted. They may need to use intermediaries or knowledge brokers who understand their needs, and also are familiar with the new area they want to explore (Roijakkers, Zynga, & Bishop, 2014).

Aurea Productiva went to each of these steps in their social-media based open innovation process. The Open Innovation Ladder indicated that the social media available in the Web 2.0 bring new opportunities and challenges for open innovation. There are new possibilities for making and using social network connections that bring about a different open innovation process.

Social media challenges for open innovation

The competitive advantages of networks created using social media over traditional contact networks are related to the concepts of reach, richness, and affiliation (Evans & Wurster, 2000). Table 12 summarizes the discussion below concerning the opportunities, challenges, and strategies for open innovation related to each of the advantages of the Web 2.0.

Web 2.0 advantage	Open innovation opportunity	Open innovation challenge	Open innovation strategy
Reach	Access to knowledge and resources	Disconnect innovation and company resources	Coevolution of innovation and resources
Richness	Frequency of interaction	Turning interaction into innovation	Sharing vision and objectives
Affiliation	People interact, not companies	Turning ideas into profit	Providing a framework for innovation

Table 12. Open Innovation strategies based on Web 2.0 advantages

Reach

Whereas traditional networks are limited to people we know or know of, social media enables us to reach further and make contact with people who have knowledge or resources we require. The reach of social media is the principal aspect generating competitive advantage compared to traditional media (Evans & Wurster, 2000). Without the limitation of physical distance and with the searchability of the network we are infinitely more likely to find what we need. The challenge for companies that want to fully exploit the potential of the Web 2.0 is then to detach innovation from the current resources of the company. In open innovation powered by social media, innovation and the resources for the innovation coevolve so that the search for knowledge and other resources is an integrated part of the innovation process (Castellacci & Natera, 2013).

Richness

The level of depth and detail in knowledge exchange is referred to as the richness of the knowledge (Evans & Wurster, 2000). Social media encourages us to interact more frequently than when we were limited to physical meetings, phone contact, or even e-mail. The increased frequency of interaction makes collaboration on innovative projects easier and more detailed. Many companies are however flooded with possibilities of interaction and face the difficulty of directing their time to the collaborations that result in innovation. For others, interactions become nothing more than social chat. Companies hence face the challenge of focusing the contacts so that they generate innovation. In open innovation powered by social media, companies share visions and objectives in order to focus interaction towards innovation. Conveying vision and objectives in an attractive and visual manner is more important than ever when innovating through the Web 2.0.

Affiliation

The interests represented by someone in an interaction is their affiliation knowledge (Evans & Wurster, 2000). In social media, people interact as individuals, not as company representatives. The interaction between individuals provides intimacy and richness to interactions, but also poses challenges for companies. The actions of employees are rarely perfectly aligned with the company goals. To profit from ideas that come up in personal interactions, companies thus need to set a framework for innovation. Google is known for its innovation framework that combines individual creativity with company strategy, e.g. allotting certain employee time to personal projects and embracing early failure to avoid disasters in completed projects.

Discussion and Conclusion

This chapter explores the open innovation process in SMEs powered by social media, and have extended our understanding of the benefits offered by social media. Companies that want to fully exploit the benefits of social media appear to create

strategy that emphasizes coevolution of innovation and resources, sharing their vision and objectives, and providing a framework for innovation.

In traditional networks, trust is often based on references from common contacts. We trust knowledge and resources because someone has recommended them to us. Although social media has functions of recommendations, trust tends to be based more on the things we have in common with the partner. For example, a farmer may put greater trust in knowledge from other farmers than from that of a research center. Trust in virtual communities is generated through providing quality content and fostering member embeddedness in the community (Porter & Donthu, 2008). Commonality-based trust has the advantage that it is instant and only requires belonging to the same group. The reliance on commonality-based trust however poses a challenge for innovation since variety of ideas favors breakthrough innovations. We are less likely to generate variety in innovation when we collaborate with people that are similar to ourselves. In open innovation powered by social media, companies therefore use intermediaries that belong to several groups and can broker knowledge from different areas.

This chapter focuses on the aspects of innovation that are particular to SMEs. This is however not a homogenous group of enterprises, and fruitful avenues for research can be found in studying how SME heterogeneous factors, such as size and industry, affect the use of social media for innovation. Such research would also allow an assessment of the circumstances under which the frameworks developed in this study are valid. An inventory of the existing social media tools for open innovation is also outside the scope of this study. A comparative analysis of such social media tools and their usefulness for innovation would surely bring additional insights. We are only beginning to understand the potential impact of social media on innovation and the strategies necessary to realize this potential.

Conclusions

Here I summarise the main conclusions of the work carried out during the PhD thesis, and explain the logic which ties the chapters together.

The first part of this thesis comprises an introduction that introduces the concept of Open Innovation, and identifies that research into Open Innovation in SMEs is in its infancy, with many studies focussing on large, multinational firms.

This literature review analyses a decade of academic work into the field of Open Innovation in SMEs, after detecting that much work into Open Innovation focuses largely on Open Innovation in large firms (Albors-Garrigós, Zabaleta Etxebarria, Hervas-Oliver, & Ganzarain Epelde, 2011; Lee, Park, Yoon, & Park, 2010). The literature I review spans the decade from 2005-2014, comprising a total of 99 peer-reviewed articles, and reveals a growing interest in the topic.

The analysis of the barriers has enabled me to provide a theoretical framework of barriers to Open Innovation in SMEs: barriers of smallness, organisation and culture; costliness; and institutional factors. In the framework I distinguish resource-based barriers (dependent on the resources the firm possesses or lacks) from transaction-cost barriers (which can affect the efficacy of transacting with other firms); and simple barriers (dependent on a few variables) from complex barriers (where there is an unknown and complex number of interactions).

The smallness barrier is classified as being simple, because it depends on only a few variables and is easy to identify, and resource-based, since it depends largely on the reduced amount of resources and capabilities available to SMEs, due to their size. SMEs need to build their competitive advantages on resources and capabilities just as do larger firms (Barney et al., 2001). However, due to the barrier of smallness, SMEs have less access to resources and capabilities. The research I have reviewed has indicated that Open Innovation is more useful for SMEs than for large firms, and that small firms can engage in open innovation more intensively than large firms (Spithoven, Vanhaverbeke, & Roijakkers, 2013). Open innovation therefore enables

small firms to overcome the barrier of smallness by providing access to resources that would otherwise be unavailable to them (Lee et al., 2010; Pullen et al., 2012). Smallness can also translate into a complex barrier, since it can impede the SME from creating the capabilities it needs to carry out successful open innovation. I classify these capabilities as organizational and cultural (van de Vrande et al., 2009).

We cannot pinpoint or isolate which organizational and cultural factors constitute barriers to SMEs, which leads me to identify them as complex barriers. One suggestion is that it is a combination of different, but intertwined factors, coupled with the unique characteristics of each SME, which shape their successful adoption of open innovation.

Costliness is also classified as simple, and transaction-based, since any transaction between two firms implies additional costs (Williamson, 1979). Working with larger firms can entail higher transaction costs (Christensen et al., 2005). Research suggests that efficient institutions could help reduce transaction-related barriers (Williamson, 2000). However, from the review, I argue that such efficient institutions are not yet in place, thus becoming another barrier to open innovation in SMEs: institutional barriers. This leads me to classify institutional barriers are complex (unknown number of variables and interactions) and transaction based. Studies have found that policy makers need to create knowledge and links between education and R&D, and foster open innovation by facilitating access to external knowledge providing institutional support (de Jong et al., 2010; Dries et al., 2014; Vigier, 2007). However, policy makers seem to be more interested in open innovation models for large firms, not SMEs (Albors-Garrigós et al., 2011). In fact, SMEs need different types of tactics when commercialising their inventions (Kang et al., 2013).

Significantly, this literature review enables me to identify a research gap. There seems to be little consensus on *how to measure the effect of open innovation activities in SMEs*. The literature provides conflicting evidence, from measuring the market results of R&D projects (Padilla-Melendez et al., 2012), using a closed innovation strategy to positively affect financial outcomes (Lee et al., 2009), to adopting new business models to enhance firm performance (Huang et al., 2013). Research suggests that SMEs should include patenting activities in their innovation strategy (Andries & Faems, 2013).

Chapter three of this thesis attempts to answer the question of how to measure *effect of open innovation activities in SMEs*. Here I link the question of open innovation and performance in SMEs, taking IPR strategies as a variable. I answer this question by using an empirical, quantitative analysis of 2,873 firms included in the Spanish Community Innovation Survey, during the years 2008-2013. The IPR strategies considered in this chapter are patents, industrial designs, trademarks and copyrights.

Most importantly, the results show that SMEs do not benefit from open innovation or from patenting in the same was as small firms do. Additionally, SMEs profit in different ways from IPR, depending on their size and the corresponding IPR.

Therefore, it cannot be demonstrated that open innovation has a clear positive impact on firm performance. This is in line with the findings of Lee et al. (2009) and Kim and Park (2010), who claim that open innovation is not always beneficial for SMEs. A possible explanation for this could be the increased costs related to open innovation, which could reduce the operating profit.

Previous studies have shown that SMEs may be unable to afford the expense of hiring external legal experts for patenting activities (Eppinger and Vladova, 2013), and that cost and lack of resources may hinder SMEs from patenting (Kalanje, 2006). Rather than applying a systematic approach to patenting, SMEs focus on innovations which they consider to have a very high probability of market success (Spithoven et al., 2013). The results also show that patenting has a negative effect on turnover in medium-sized firms, contradicting earlier studies which suggest a positive link between patenting and firm performance in SMEs (Andries and Faems, 2013; Spithoven et al., 2013). This may be a result of the fact that SMEs in Europe tend to patent less than large firms in general.

As for industrial designs, the study shows that the use of this IP strategy is low. The results do not show a positive link between firm performance of small firms and industry design usage. On the other hand, the most used IPR in the sample is trademarks. Previous research has shown that trademarks typically generate a very high IRP revenue (Doern, 1999), and that these rights are fairly cheap and easy to access, while offering protection to a product (Mendonca, et at. 2004). However, the

investigation shows that the use of trademarks in combination with open innovation is complex, and that any positive short-term effects may in fact be cancelled out by negative long-term effects.

The last IPR tested was copyrights, which was the least used of the four. The findings indicate that companies do not use copyrights strategically, and that relying on copyrights for IP protection does not help firm performance.

Perhaps the most significant conclusion that can be drawn from the empirical analysis of IPR strategies combined with open innovation is that inefficient use of open innovation in SMEs may be an obstacle to SMEs in reaping the benefits of openness. In fact, it is argued that a more targeted use of copyrights may be useful due to the low costs and ease of formal application, which can be employed by small firms. It is the responsibility of institutions and policy makers to support more efficient patenting and trademarking processes. This therefore supports some of the conclusions of the literature review in chapter two: institutional barriers remain an important barrier to open innovation in SMEs.

The final chapter comprises a qualitative investigation into how to use social media to conduct effective open innovation in SMEs. I attempt to answer the question *how social media can be used to carry out open innovation in SMEs*. A case-study approach is employed in order to study the case of open innovation in a start-up, and provide a framework for open innovation in SMEs powered by social media: the Open Innovation Ladder.

The Open Innovation ladder is a series of rungs, or steps, which enable the firm to close the collaboration gap. The following steps are identified: vision (without which the ladder will collapse); innovation gap (what type of innovations we need to achieve our vision); collaboration gap (the resources we need to close the innovation gap); and broker gap (who to connect with to successfully collaborate).

Additionally, a series of social media challenges for open innovation are identified. Firstly reach: social media enables us to reach more people and further away who have the knowledge and resources that we need. The challenge is to integrate the Web 2.0

into the innovation process in order to fully exploit its potential. The second challenge is richness: social media provides more frequent interaction, which makes collaboration easier. However, the challenge is to focus this interaction on innovation. The next challenge is affiliation: while interaction between individuals provides intimacy and richness, employee actions are rarely aligned with company goals. The challenge therefore is to set a framework for innovation.

To conclude the fourth chapter, I argue that we are less likely to generate innovation when we collaborate with people that are similar to ourselves. It is a variety of ideas which favours breakthrough innovations, and social media provides access to several groups with knowledge of different areas. In a nutshell, innovation powered by social media allows companies to use intermediaries from several groups in order to broker knowledge from different areas.

As with all studies, this thesis is not without its limitations. Firstly, the chapter concerned with the literature review spans a decade of research, up to 2014. A further review of the academic work published since then may find different barriers to open innovation in SMEs, or may lead to a new classification of these barriers. It is entirely possible that there is more work on the outcomes of open innovation in SMEs, that is, how to measure the effectiveness of engaging in open innovation. Perhaps academics have found a reliable way to measure and even predict if engaging in open innovation is, or will be, profitable for SMEs.

In the third chapter of this thesis, I provide an empirical study of the outcomes of open innovation in SMEs, and investigate the impact of IPR strategies. However, a major limitation is that while the IPR activity itself is analysed, the impact of the IPR is not. Additionally, the study focuses on Spain. Future research should investigate whether the findings translate to other countries and regions, particularly in the European Union, with its diverse markets. Another key limitation is that secrecy is a significant form of protection for businesses, which cannot be measured with IP data. Therefore, future research could analyse the relationships between the use of secrecy and other IP options.

Finally, the fourth chapter provides an insight into social media practices for open innovation in SMEs. Since this chapter is a single business case study, and SMEs are not a homogenous group, further studies research could study how factors such as size and industry affect how social media can create innovation.

It is clear that there are many ways in which research can make valuable contributions to the study of open innovation in small and medium-sized enterprises. While research into open innovation in SMEs is still in its initial stages, studies of open innovation in general are gaining momentum. Such rapid progress requires continued revision of frameworks and conclusions.

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Appendices

Appendix 1: A summary of publications on open innovation in SMEs

Reference	Journal	Keywords	Method	Setting
Albors-Garrigós, J., Etxebarria, NZ., Hervas-Oliver, JL., and Epelde, JG. (2011)	International Journal of Technology Management	Open innovation, OI, small and medium enterprises, SMEs, outsourced innovation.	Quantitative	Questionnaire / personal interviews with the managers of 22 R&D units in the Basque Country.
Alexy, O., and George, G. (2013)	Journal of Management Studies	Category emergence, open innovation, open source software, organizational legitimacy, valuation.	Quantitative	Press announcements: 236 events by 96 firms.
Allarakhia, M., and Walsh, S. (2011)	Technovation	Technology, entrepreneurship, biology, chemistry, nanotechnology, knowledge management, intellectual property.	Qualitative	Case-study analysis of 26 bio-pharmaceutical consortia.
Andries, P., and Faems, D. (2013)	Journal of Product Innovation Management	Not specified.	Quantitative	358 Belgian manufacturing firms: 235 SMEs and 120 large firms.

Anokhin, S., Örtqvist, D., Thorgren, S., and Wincent, J. (2011)	Long Range Planning	Not specified.	Quantitative	652 annual investment decisions (163 corporations over 4 years from 1998 to 2001).
Anthony, S. (2012)	Harvard Business Review	Not specified.	Conceptual	
Belussi, F., Sammarra, A., and Rita Sedita, S. (2008)	European Planning Studies	Not specified.	Quantitative	Life science cluster of Emilia Romagna (Italy). R&D collaborative activities in 30 public research organisations and 78 private firms.
Berkhout, AJ., Hartmann, D., Van Der Duin, P., and Ortt, R. (2006)	International Journal of Technology Management	Innovation; change; creativity; entrepreneurship; knowledge management; knowledge economy; innovation management; innovation economy; sociotechnical; socioeconomic; Lisbon strategy.	Conceptual	
Bianchi, M., Campodall'Orto, S., Frattii, F., and Vercesi, P. (2010)	R&D Management	Not specified.	Qualitative	1 Italian SME operating in the packaging industry.
Bocken, N.M.P., Farracho, M., Bosworth, R., and Kemp, R. (2014)	Journal of Engineering and Technology Management - JET-M	Fuzzy front end, eco-innovation, eco-design, new product development, sustainability.	Quantitative	42 Dutch SMEs who applied for the Dutch "Columbus' Egg" prize for sustainability innovations. All manufacturing, over a wide range of sectors.
Brown, R., and Mason, C. (2014)	Technovation	Technology based firms, technology policy, innovation systems entrepreneurship, public policy, UK	Mixed	7,462 Technology Based Firms in Scotland.

Brunswicker, S., and Vanhaverbeke, W. (2014)	Journal of Small Business Management	Not specified.	Quantitative	1411 European SMEs.
Bullinger, A., Rass, M., Adamczyk, S., Moeslein, K., and Sohn, S. (2012)	Health Policy	Open innovation, public integration, health care, communication.	Qualitative	German open health platform.
Caetano, M., and Amaral, D. (2011)	Technovation	Partnerships, innovation, integration strategy, technology development.	Quantitative	Not specified.
Chaston, I. (2012)	Australian Journal of Adult Learning	Universities, funding, knowledge management systems, open innovation.	Quantitative	Survey of 138 academics of second-tier UK universities.
Chaston, I., and Scott, G.J. (2012)	Management Decision	Entrepreneurship, learning styles, knowledge acquisition, open innovation, entrepreneurialism, innovation.	Quantitative	Questionnaire to 238 managers enrolled in the Catholic University of Lima's post graduate programs in business administration.
Chesbrough, H., Kim, S., and Agogino A. (2014)	California Management Review	Not specified	Qualitative	Single-firm case study.
Christensen, J.F., Olesen, M.H., and Kjær, J.S. (2005)	Research policy	Consumer electronics, digital amplification, open Innovation, system of innovation, technological regime, technology entrepreneurs.	Qualitative	Electronics sector in Denmark.
Clausen, T., and Rasmussen, E. (2011)	Technology Analysis & Strategic Management	Additionality, entrepreneurship, evaluation, incubators, innovation policy, open innovation.	Qualitative	Case study of 5 incubator managers, 3 mother companies, 3 start-up firms connected to incubators. Norway.

Clausen, T.H., Korneliussen, T., and Madsen, E.l. (2013)	Technovation	Innovation mode, exploration, exploitation, open innovation, closed innovation, product innovation.	Quantitative	Over 1,000 R&D active firms in Norway
Colombo, M. G., Piva, E., and Rossi-Lamastra, R. (2014)	Research Policy	Open innovation, within-industry diversification, small and medium enterprises, open source community.	Qualitative	100 European open source software firms.
Comacchio, A., Bonesso, S., and Pizzi, C. (2012)	Journal of Technology Transfer	Boundary spanning, technology transfer centres, university-industry linkage, SMEs, joint R&D projects, human capital.	Quantitative	Survey of 148 Technology Transfer Centres in the regions in North East Italy.
Cooke, P. (2005)	Research Policy	Regionalisation, open innovation. asymmetric knowledge, "globalisation 2"	Qualitative	Case study of pharmaceutical biotechnology and agro-food technology industries in Basel, Switzerland.
Cossío Silva, F.J., Camacho, M.A., and Vega Vázquez, M. (2013)	International Entrepreneurship and Management Journal	Value co-creation, heterogeneity, latent class segmentation, service firms, entrepreneurs.	Quantitative	547 Spanish firms in sectors of hairdressing and aesthetics. Mostly SMEs.
De Jong, J.P.J., Kalvet, T., and Vanhaverbeke, W. (2010)	Technology Analysis & Strategic Management	Open innovation, policymaking, national innovation systems, market failure, system failure.	Conceptual	Open innovation and guidelines for policy making. Netherlands, Flanders, and Estonia.
Dove, E. S., Özdemir, V., and Joly, Y. (2012)	Drug Development Research	Database, data-intensive science, omics sciences, open innovation, theranostics..	Conceptual	
Dries, L., Pascucci, S., Török, Á., and Tóth, J. (2014)	International Food and Agribusiness Management Review	Open innovation, dynamic capabilities, dynamic capabilities, Hungary, wine.	Quantitative	Hungarian Wine Sector. 115 questionnaires completed.

Du, J., Leten, B., and Vanhaverbeke, W. (2014)	Research Policy	Open innovation, R&D collaboration, R&D project, Project management.	Quantitative	Large multi-national European manufacturing firm.
Dunlap-Hinkler, D., Kotabe, M., and Mudambi, R. (2010)	Strategic Entrepreneurship Journal	Corporate entrepreneurship, breakthrough and incremental innovation, open innovation, organizational ambidexterity, foreign subsidiaries, strategic alliances.	Quantitative	US, pharmaceuticals. 1496 to 1699 new drug applications from 98 firms.
Dushnitsky, G., and Kleuter, T. (2011)	European Management Review	Market for ideas, entrepreneurship, innovation, open innovation, venture capital.	Quantitative	30 online knowledge marketplaces.
Eppinger, E., and Vladova, G. (2013)	International Journal of Technology Management	IP management, intellectual property rights, IPR, IP strategy, patents, pharmaceutical industry, practice theory, small and medium-sized enterprise, SME.	Qualitative	Case study.
Felício, J.A., Caldeirinha, V.R., Rodrigues, R., and Kyvik, O. (2013)	International Entrepreneurship and Management Journal	Global mindset, global orientation, small firms, internationalization behaviour.	Quantitative	143 Norwegian firms and 211 Portuguese firms with international activities.
Ferrary, M. (2011)	European Management Journal	Ambidexterity, A&D, open innovation, high-tech cluster, Silicon Valley, venture capital firms.	Qualitative	Comparison of Lucent Technologies and Cisco Systems.
Fujiwara, T. (2014)	Technology Analysis & Strategic Management	Biotech start-up, strategic partnership, real options, stochastic optimisation.	Qualitative	Biotech start-ups.

Germann. P. G., Schuhmacher A., Harrison, J., Law. R., Haug, K, and Wong, G. (2013)	Human Genomics	Healthcare industry, corporate venture capital, open innovation, new frontier science, translational development, technology platforms.	Conceptual	
Gruber, M., and Henkel, J. (2006)	International Journal of Technology Management	Embedded Linux, entrepreneurship, innovation, liabilities of newness and smallness, open source innovations.	Qualitative	30 in-depth interviews (focus: open source development process); 13 software firms, 6 hardware manufacturers, 7 industry experts, 4 work directly with embedded Linux.
Haefliger, S., Jäger, P., and Von Krogh, G. (2010)	Research Policy	User innovation, user entrepreneur, market entry, intellectual property, complementary assets, Machinima.	Qualitative	Video gaming: observations and retrospective data of 7 firms.
Harryson, S.J. (2008)	R&D Management	Not specified.	Qualitative	Case study of Anoto.
Hayter, C.S. (2013)	Economic Development Quarterly	Entrepreneurship, technology transfer, economic development.	Quantitative	Database of academic entrepreneurs in the US. 117 individuals responded.
Herskovits, R., Grijalbo, M., and Tafur, J. (2013)	International Entrepreneurship and Management Journal	Open innovation, value creation, value drivers, value-based management, corporate venture capital.	Conceptual	
Holm, A.B., Günzel, F., and Ulhøi, J.P. (2013)	International Journal of Technology Management	Business model, business model innovation, open business model, internet, newspaper industry, open innovation, technological discontinuities, business model openness.	Qualitative	12 interviews with informants from the two largest national privately-owned newspaper publishers in Denmark.

Hronszky, I., and Kovács, K. (2013)	Acta Polytechnica Hungarica	Open innovation, living lab, harmonization cube, SME involvement.	Conceptual	
Huang, H., Lai, M., Lin, L., and Chen, C. (2012)	Journal of Organizational Change Management	Business model innovation, inbound open innovation, organizational inertia, outbound open innovation.	Quantitative	141 manufacturing SMEs in Taiwan.
Hung, K.P., and Chaing, Y.H. (2010)	International Journal of Technology Management	Open innovation, open innovation proclivity, entrepreneurial orientation, firm performance.	Quantitative	122 Taiwanese electronic manufacturing firms.
Idelchik, M., and Kogan, S. (2012)	Research-Technology Management	Open collaboration, open innovation, clean tech, healthcare, adjacencies.	Qualitative	Case study of GE.
Jacobsen, E., and Schouten, H.J. (2009)	Euphytica	Cisgenesis, GM-regulations, linkage drag, derogation, exemption, inventions.	Conceptual	
Jeon, J., Lee, C., and Park, Y. (2011)	Journal of Intellectual Property Rights	Open innovation, technology partner, patent analysis, technology alliance.	Quantitative	Technological need data extracted from yet2.com; 5,096 patents, compared with the original need documents.
Kang, J., Gown, S.H., Kim, S., and Cho, K. (2013)	Asian Journal of Technology Innovation	Technology commercialization, commercialization strategy, government-sponsored SME, innovative capability, open innovation activity.	Quantitative	1,192 firms supported by government programmes in technological innovation processes (156 large firms and 1,036 SMEs). Data from Korean Innovation Survey.

Katzy, B., Turgut, E., Holzmann, T., and Sailer, K. (2013)	Technology Analysis & Strategic Management	Open innovation, collaboration, innovation process, innovation value chain, SME, deal flow portfolio, innovation valuation.	Qualitative	Action study of seven innovation projects with collaborative partnerships in inter-organisational networks. Europe, automotive industry.
Kim, H., and Park, Y. (2010)	International Journal of Technology Management	Open innovation, external R&D, external knowledge, external idea, small and medium-sized enterprises, SMEs, Bayesian network, Korea.	Quantitative	Data from KIS. 1,140 SMEs, 244. Total observations 1,384.
Kirschbaum, R. (2005)	Research-Technology Management	Open innovation, creating value, venturing, business development.	Qualitative	Case study of Dutch State Mines (multinational life sciences and performance materials company).
Knörr, H., Alvarez, C., and Urbano, D. (2013)	International Entrepreneurship and Management Journal	Entrepreneurship, entrepreneurial behaviour, creativity, risk taking, independence, institutional economics.	Quantitative	Data obtained from the World Values Survey, from 2005-2008. Sample of 41 countries and 56,875 individuals.
Kutvonen, A. (2011)	European Journal of Innovation	Outbound open innovation, strategy, open innovation, external commercialization, technology management, innovation, management strategy.	Literature review	

Lasagni, A. (2012)	Journal of Small Business Management	Not specified.	Quantitative	56,5% industry 40% services 3,5% other firms in six European countries (Austria, Germany, Italy, Hungary, Poland and Slovenia).
Lassala, C., Momparler, A., and Carmona, P. (2013)	International Entrepreneurship and Management Journal	Independent financial advisors, financial services, networking, open innovation.	Quantitative	IFAs located in Spain.
Lee, S., Park, G., Yoon, B., and Park J. (2010)	Research Policy	Open innovation, SME, network, intermediary, case study.	Conceptual	Korean SMEs (Technology Innovation Survey published by STEPI: Science and Technology sectors).
Lee, Y.G., Park; S.H., and Song, Y.I. (2009)	Asian Journal of Technology Innovation	Open innovation, SMEs, financial performance, closed innovation, R&D outsourcing.	Quantitative	215 Korean SMEs from semiconductor, software, pharmaceutical, chemical and mechanical industries.
Lundström, A., and Zhou, C. (2011)	Innovation - The European Journal of Social Science Research	Innovation based on social S&T, science and technology park (STP, social innovation park (SIP), academic entrepreneurship. triple helix. open innovation.	Conceptual	
Marcelino-Sádaba, S., Pérez-Ezcurdia, A., Echeverría Lazcano, A.M., and Villanueva, P. (2014)	International Journal of Project Management	Small firms, project risk management methodology, strategic risks.	Conceptual	
Matsumoto, H., Yamamura, T., and Maruyama, F. (2010)	Fujitsu Scientific and Technical Journal	Not specified.	Qualitative	Case study of Fujitsu.

Mayer, H. (2010)	Economic Development Quarterly	States, science and technology, open innovation, public policy.	Qualitative	Case studies R&D investment efforts in the US.
Medina Molina, C., Rufín Moreno, R., and Rey Moreno, M. (2013)	International Entrepreneurship and Management Journal	Previous beliefs, attitudes, continuance, E-learning.	Qualitative	E-learning platform.
Minshall, T., Mortara, L., Valli, R., and Probert, D. (2010)	Research-Technology Management	Partnerships, start-up, large firms, open innovation.	Qualitative	12 case studies of high-tech start-ups operating in UK.
Mok, K. H. (2013)	Asia Pacific Education Review	Entrepreneurial university, academic freedom, managerialism and university governance, global competitiveness.	Quantitative	Higher education in East Asia.
Moon, S. (2011)	Asian Journal of Technology Innovation	Open innovation, Korean service industry, determinants of openness, entrepreneurship, absorptive capacity.	Quantitative	2,498 enterprises in service industries. Survey. (Data from the Korean Innovation Survey (KIS) on the service sector (2006).)
Mortara, L., Ford, S. J., and Jaeger, M. (2013)	Technological Forecasting and Social Change	Idea competitions, innovation tournaments, innovation contests, crowdsourcing, open innovation, acquisition mechanism, intelligence, user innovation, public relations.	Qualitative	5 interviews with large firms which run IC competitions, and 1 interview with an IC intermediary.
Napp, J, and Minshall, T. (2011)	Research-Technology Management	Corporate venturing, corporate venture capital, open innovation, value creation, strategic value.	Qualitative	9 case studies of corporate venturing units in large corporations.
Neyens, I., Faems, D., and Sels, L. (2010)	International Journal of Technology Management	Startup, time frame, alliance strategy, innovation performance.	Quantitative	217 Flemish start-ups.

Noguera, M., Alvarez, C., and Urbano, D. (2013)	International Entrepreneurship and Management Journal	Female entrepreneurship, women entrepreneurship, socio-cultural factors, institutional economics, GEM, Catalonia.	Quantitative	Catalonia Global Entrepreneurship Monitor project for 2009 and 2010, sample of 4,000 randomly selected individuals.
Padilla-Meléndez, A., and Del Aguila-Obra, A.R. (2012)	International Small Business Journal	Academic entrepreneurship, knowledge transfer and exchange (KTE), open innovation, social capital, spin-off SMEs.	Qualitative	18 in-depth interviews with academic entrepreneurs, most from Technological Park of Andalucía, Spain.
Parida, V., Westerberg, M., and Frishammar, J. (2012)	Journal of Small Business Management	Not specified.	Qualitative	High-tech SMEs.
Pullen, A. J. J., De Weerd-Nederhof, P. C., Groen, A. J., and Fisscher, O. A. M. (2012)	Journal of Product Innovation Management	Not specified.	Mixed	60 Dutch medical-devices SMEs.
Ritala, P., Henttonen, K., Salojärvi, H., Sainio, L., and Saarenketo, S. (2013)	Baltic Journal of Management	Knowledge, open knowledge search, open innovation, strategic orientations, exploration, antecedents, knowledge management, innovation.	Quantitative	193 Finish companies with more than 100 employees which undertake R&D activities.
Rolandsson, B., Bergquist, M., and Ljungbery, J. (2011)	Research Policy	Open source software development, professional programmers, tensions, strategies.	Qualitative	Interviews with programmers from 15 pure-play and 15 hybrid companies.
Rubinelli, S., Collm, A., Glässel, A., Diesner, F., Kinast, J., Stucki, G., and Brach, M. (2013)	Patient Education and Counselling.	Consumer health websites, internet, spinal cord injury, self-management, open communities, innovation.	Qualitative	Case study of interactive website in the field of spinal cord injury (SCI).

Saguy, S., Sirotinskaya, V. (2014)	Trends in Food Science and Technology	Curricula, economic and social effects, innovation, food industries, future challenges, open innovation, small and medium enterprise, social responsibilities, special needs.	Literature review	
Spithoven, A., Clarysse, B. and Knockaert, M. (2011)	Technovation	Open innovation, absorptive capacity, technology intermediation.	Qualitative	Interviews with CEOs of Collective Research Centres.
Spithoven, A., Vanhaverbeke, W., and Roijakkers, N. (2013)	Small Business Economics.	Open innovation, SMEs, large enterprises, product innovation, innovative performance.	Quantitative	967 Belgian SMEs.
Suh, Y., and Kim, M.S. (2012)	Innovation: Management, policy & practice	Collaborative activity, collaboration, open innovation, efficiency, service SMEs, R&D in the service sector, data envelopment analysis (DEA).	Quantitative	300 datasets from the 2006 Korean Innovation Survey of the service sector. SMEs.
Teirlinck, P., and Spithoven, A. (2013)	Technovation	Research manager, R&D expert, R&D training, research collaboration, R&D outsourcing, SME, firm size.	Quantitative	37 very small, 61 small and 42 medium-sized Belgian firms (total 140).
Török, Á., and Tóth, J. (2013)	Agricultural Economics (Czech Republic)	Hungarian SMEs, open innovation, principal component analysis, vine- and wine sector.	Quantitative	Survey in 22 Hungarian wine regions. 119 questionnaires answered.
Traitler, H., Watzke, H.J., and Saguy, I.S. (2011)	Journal of Food Science	Innovation partnerships, sharing-is-winning model, strategic alliance, value chain.	Qualitative	
Tranekjer, T. L., and Knudsen, M. P. (2012)	Journal of Product Innovation Management	Not specified.	Quantitative	355 Dutch SMEs in manufacturing industries and R&D.

Tranekjer, T.L., and Søndergaard, H.A. (2013)	International Journal of Technology Management	Open innovation, mix of external sources, tie strength, relational embeddedness, knowledge redundancy, NPD project level performance.	Quantitative	Questionnaire 342 Danish manufacturing SMEs with knowledge of and interest in NPD area.
Urbano, D., and Turró, A. (2013)	International Entrepreneurship and Management Journal	Corporate entrepreneurship, intrapreneurship, resource-based theory, institutional economics, global entrepreneurship monitor, GEM.	Quantitative	Data from the Global Entrepreneurship Monitor. 9 European countries (Greece, Spain, Italy, Ireland, the Netherlands, France, the United Kingdom, Denmark and Finland).
Van de Borgh, M., Cloodt, M., and Romme, A. G. L. (2012)	R&D Management	Not specified.	Qualitative	33 High Tech Campus Eindhoven managers and residents.
Van de Vrande, V., de Jong, J. P. J., Vanhaverbeke, Wim., and de Rochemont, M. (2009)	Technovation	Open innovation, SMES, technology markets, incidence, perceived trend, motives, managerial challenges.	Qualitative	605 Dutch SMEs.
Van Hemert, P., Nijkamp, P., and Masurel, E. (2012)	Annals of Regional Science	Not specified.	Quantitative	243 Dutch SMEs that had applied for an innovation voucher in the period 2006-2009.
Vigier, P. (2007)	Innovation - The European Journal of Social Science Research	Not specified.	Conceptual	
Vrgovic, P., Vidicki, P., Glassman, B., and Walton, A. (2012)	Innovation: Management, policy & practice	Open innovation, collaboration, independent inventors, idea generation, communication.	Conceptual	

Waguespack, D.M., and Fleming, L. (2009)	Management Science	Open innovation, standards, entrepreneurship.	Quantitative	1,141 U.S.-based venture-backed start-ups. Internet communications or data communications industry sectors.
Walsh, S.T., and Linton, J.D. (2011)	Technological Forecasting and Social Change	Model, technology, innovation, entrepreneurship, commercialization, physical and service products.	Qualitative	Case study of 2 large firms, 2 SMEs, and 2 situations involving a decision to work with outside organisations.
Wei, C.C., Lu, I.Y., Kuo, T., and C, S.C. (2013)	Chinese Management Studies	Bandit, innovation, strategy, enterprise development, open innovation, system dynamics, China.	Qualitative	Case study of Chinese bandit device makers (electronics).
Wincent, J., Anokhin, S., and Boter, H. (2009)	R&D Management	Not specified.	Quantitative	Swedish small-firm networks.
Wouters, M., Workum, M., and Hissel, P. (2011)	R&D Management	Not specified.	Qualitative	Case study of pilot project.
Wu, Y., Lin, B., and Chen, C. (2013)	IEEE Transactions on Engineering Management	Innovation capabilities, open innovation, openness.	Quantitative	Questionnaire 393 firms in fast-moving, R&D-intensive sectors.
Wynarczyk, P., Piperopoulos, P., and McAdam, M. (2013)	International Small Business Journal	Collaborative approach, open innovation, SMEs.	Literature review	
Xiaobao, P., Wei, S., and Yuzhen, D. (2013)	International Journal of Technology Management	Open innovation, emerging market small and medium enterprises, EM SMEs, network framework, network information, competitive advantage, technology management.	Quantitative	264 questionnaires with SME executives in China.

Zeng, S. X., Xie, X. M., and Tam, C. M. (2010)	Technovation	Innovation, cooperation network, innovation performance, SMEs.	Quantitative	Chinese manufacturing sector.